LETTERS

ON THE

PHYSICAL HISTORY OF THE EARTH,

ADDRESSED TO

PROFESSOR BLUMENBACH:

CONTAINING

GEOLOGICAL AND HISTORICAL PROOFS OF THE DIVINE MISSION OF MOSES.

Jean André

BY THE ~~LATE~~

J. A. DE LUC, F.R.S.

PROFESSOR OF PHILOSOPHY AND GEOLOGY AT GOTTINGEN.

TO WHICH ARE PREFIXED

INTRODUCTORY REMARKS AND ILLUSTRATIONS;

TOGETHER WITH

A VINDICATION OF THE AUTHOR'S CLAIMS TO ORIGINAL VIEWS RESPECTING FUNDAMENTAL POINTS IN GEOLOGY.

BY THE

REV. HENRY DE LA FITE, A.M.

OF TRINITY COLLEGE, OXFORD,

AND MEMBER OF THE ROYAL SOCIETY OF LITERATURE.

LONDON:

PRINTED FOR C. J. G. & F. RIVINGTON,

ST. PAUL'S CHURCH-YARD,

AND WATERLOO-PLACE, PALL-MALL.

1831.

LONDON:
GILBERT AND RIVINGTON, PRINTERS,
ST. JOHN'S SQUARE.

ADVERTISEMENT.

In laying the following sheets before the Public, it may, perhaps, be proper for the Editor to state, that those parts of the present publication for which he is responsible, have gradually grown under his hands to a more considerable bulk than he at first contemplated. This increase was the natural result of a desire on his part, to render the work as useful to his readers as was in his power, and at the same time to vindicate the title of his venerable friend—for such he had the privilege of esteeming the author—to the gratitude of the world. With regard to the evidences, which in consequence of the latter design, may occasionally appear, of the Editor's personal regard and affection for that great man, of whose extensive labours in the domains of science, the following Letters are a small, though an important

fragment, he considers that no apology is needed, so long as those sentiments have not—and he trusts they have in no degree—blinded his judgment to the merits of the illustrious successors of De Luc, the heirs and improvers of his discoveries.

LONDON,
May 10, 1831.

CONTENTS OF THE INTRODUCTION.

PAGE

PRELIMINARY OBSERVATIONS 1

SECTION I.

General object of the Work 4

SECTION II.

Fundamental point in Geology established by De Luc—Geological Chronometers—Residence of the Sea upon extensive portions of our Continents for a considerable time immediately before the last revolution 8

SECTION III.

Connection between the Mosaic Narrative of the Deluge and Geological Phenomena 33

SECTION IV.

Two Periods in the History of the earth—one prior, the other posterior to the existence of our Continents—In the latter Period there is a fixed Chronology: in the former, a series of Geological Events may be traced, in which we discern only a succession of subordinate epochs, without determination of time—Summary view of that series—Origin assigned to the Mineral Strata and to the Atmosphere—Successive changes in the nature of our Mineral Beds; disturbances which they have suffered—Causes of those two great Phenomena of Geology indicated—Proofs of changes, at several epochs, both in the Liquid of the Sea, and in the Atmosphere 39

SECTION V.

PAGE

Agreement of Cuvier and Alex. Brongniart with De Luc in his General Statement of Geological Phenomena, and his Views respecting the Causes and Operations that relate to them.......... 76

SECTION VI.

Mosaic Days, to be considered as Indefinite Periods—Arguments in support of that Opinion—Ancient and Modern Authorities—Connection between the Mosaic Narrative of the CREATION, and Geological Phenomena 86

SECTION VII.

General Inferences—A true Theory in Geology not undiscoverable—Approximations to such a Theory by De Luc..... 118

SECTION VIII.

Moral importance of Geology—Means of facilitating its study indicated by De Luc.................................... 131

CONTENTS OF THE LETTERS.

LETTER I.

PAGE

On the Phenomena characterizing the Causes that have formerly operated upon the Terrestrial Globe; and particularly on those which fix the date of the Origin of our Continents 1

LETTER II.

Analysis of Geological Phenomena, leading to a determination of their Origin 41

LETTER III.

On the History of the Earth, from the origin of what is now observed upon it, down to the production of the Strata of Sand-stone 81

First Period 83
Second Period 93
Third Period 105
Fourth Period 111
Fifth Period 116

LETTER IV.

On the History of the Earth, from the time of the formation of the calcareous strata, to the last period in which the Sea remained in its ancient Bed; a long space of time, which comprises, in particular, the Origin of Volcanic Eruptions and of Coal Beds; the formation of the strata of Chalk and Rock Salt; and the History of the Quadrupeds, of which we find the remains in our strata.... 137

Of Volcanic Eruptions 137
Of Coal Beds 155
Of the Strata of Chalk 166
Of Rock Salt 172
Sixth Period 173
Of Fossil Bones 176

LETTER V.

PAGE

Birth of our Continents—Proofs of the little distance of that epoch 182

History of the Earth since the birth of our Continents............ 190

LETTER VI.

A Physical Commentary on the eleven first Chapters of Genesis.... 230

APPENDIX.

Containing Remarks on some erroneous representations relative to the Author, in a work entitled, "A Comparative Estimate of the Mineral and Mosaical Geologies"................................ 273

ERRATA.

Introduction, Page 19, line 24, note, *after* elevation, *omit* inverted commas.
—— 32, — 18, note, *add* inverted commas after England.
—— 105, —— note, *for* "*as the matter shall require*," *read* "*at all times, as the matter shall require*."
—— 114, — 20, *after* animals, *read* Lectures on the History of the Natural Sciences.
Letters, —— 15, last line but one, *for* Section II. Although interchanges of land, *read* Section IV. page 71, line 4.
—— 38, — 9, add inverted commas, note, notwithstanding, however.
—— 107, — 14, *for* these *read* our continents.

INTRODUCTORY REMARKS

AND

ILLUSTRATIONS.

THE ardour with which the study of Geology has for several years past been prosecuted in this country, has induced the editor to lay before the public the following Letters to Prof. BLUMENBACH, written by a naturalist who is justly entitled to be considered as one of the founders of that important and comprehensive science [1].

These Letters, which originally appeared in the British Critic for 1793, 1794, and 1795, were carefully revised, and in great part recomposed by the author, for the edition published at Paris in 1798, under the title of "Lettres sur l'Histoire Physique de la Terre." To that edition constant reference has been made, and the numerous additions which it

[1] It may perhaps be worth stating, that the name by which this science is now universally known, was invented by DE LUC. Having in the "Lettres physiques et morales sur l'Histoire de la Terre et de l'Homme," employed the word Cosmology, he adds in a note: "By cosmology, I mean here the knowledge of the earth only, and not that of the universe. *Geology* would, in this sense, have been the proper word; but I am afraid to employ it, because it is not in use."

contains are introduced in the present publication. A few of the notes of the original, containing matter only of inferior interest at the present time, are suppressed. The translation also has been corrected throughout, and in many places an entirely new version is given. The sixth Letter, entitled, "A Physical Commentary on the eleven first chapters of Genesis," was subjoined, with the author's approval, to the editor's translation of his Elementary Treatise on Geology, published in 1809.

The present edition will likewise derive additional value from some original communications with which the editor has been favoured by M. J. A. DE LUC[1], of Geneva, nephew of the author, consisting of observations made by himself and other foreign geologists, on some of the most interesting subjects of the science,—such as the different granites, stratified and unstratified,—the structure of the Alps, in reference to the transversal and longitudinal valleys, — the transportation of granite blocks, &c. Some of these observations will be inserted in this Introduction, and others annexed in the form of notes to the Letters, as the different subjects under consideration shall require such illustration.

To the French edition of these Letters the author frequently adverts in his later publications, as containing an exposition of the whole of his system, and exhibiting the general results of geological observation

[1] The able author of the "Histoire du Passage des Alpes par Annibal," and of several scientific dissertations inserted in the "Bibliothèque Universelle de Genève," and the Transactions of the "Société de Physique et d'Histoire Naturelle" of that city.

and experience; at the same time pledging himself to produce satisfactory proofs of those results in his "Travels."

Geology, according to the definition of De Luc, includes not only a knowledge of the phenomena exhibited at the earth's surface, but also the investigation of the physical causes from which the actual state of the globe has proceeded[1]. With regard to this last department of the science, where the enquiry depended in great part on experimental philosophy, and especially on chymistry, our author fulfilled his engagement to the public in the two following works which appeared in Paris:—"Introduction à la Physique terrestre par les fluides expansibles." 2 vols. 1803[2]. "Traité Elémentaire sur le fluide electro-galvanique." 1804. Discussions on some of the principal branches of the above-mentioned sciences will also be found in "Précis de la philosophie de Bacon, et des progrès qu'ont fait les sciences naturelles par ses préceptes et son exemple." 2 vols. 1802; in a series of Letters[3], addressed to M. DE LA MÉTHERIE, in the Journal de Physique, from the year 1790, to 1793 inclusive; in several papers presented to the Royal

[1] Abrégé de Géologie, pp. 1. 13. Paris, 1817.

[2] In that work, which is intended to show the connection of geology with the other branches of physics and natural history, De Luc examines various meteorological theories; and proves, by direct experiments, that *light*, as a substance, enters into the composition of all the atmospherical fluids, and is the first cause of their expansibility.

[3] Frequent references to those valuable dissertations on the most interesting subjects of physical science, and occasional extracts from them, will be found in this Introduction, and in the Notes to the Letters.

Society, and in others published in Nicholson's Philosophical Magazine, 1812 and 1813.

A longer time, however, was required to fulfil his promise with respect to his geological travels, as it was necessary for that purpose to arrange the observations which were contained in his numerous journals. These observations were subsequently laid before the public in the following order:—"Geological Travels," in three volumes, published (by Rivingtons) in 1810 and 1811;—the first volume consisting of "Travels in the north of Europe, containing observations on some parts of the coasts of the Baltic, and the North Sea;" and the two following volumes, comprising "Travels in England."—"Geological Travels in some parts of France, Switzerland, and Germany." 2 vols. Rivingtons, 1813.

The results of the long and laborious researches of this great and indefatigable geologist are thus embodied in numerous works, which, while they place him on a level with the most distinguished philosophers of the age, justly entitle him also to be ranked among the most zealous and powerful advocates of revealed religion.

SECTION I.

General object of the Work.

To point out the close connection to be traced between nature and Revelation, is the professed object of the present work. With this view, the author has demonstrated that an entire conformity exists between

the facts of geology and the history of the deluge, as contained in the sacred records, where we find that event described as having resulted from the destruction of ancient continents which the sea overwhelmed;—he has further shown that the antiquity of our continents is not greater than the Mosaic chronology ascribes to them from the flood;—and he has moreover satisfactorily manifested the striking exactness with which the account of the successive formation of the globe as given in the narrative of the inspired writer, agrees with the discoveries of natural history, and the principles of sound philosophy.

With respect to the last point, De Luc says:—"When well informed men shall come seriously to attend to the relation that subsists between the circumstances characteristic of each of the Mosaic 'days,' and what has passed on our globe in the periods corresponding, proved by monuments open to every one's observation, they will acknowledge that nature herself pays homage to that sacred and sublime history [1]."

The author, however, desires it to be distinctly understood that he has not placed the correspondence between geology and the Book of Genesis among the *proofs* of his system: "I have explained it," he observes, "for the purpose of fixing more strongly the attention of my readers; but I have never recurred to it for the support either of the facts which I have brought forward, or for the conclusions which I have deduced from these facts; for this would have been a *petitio principii.* On this great point, truth has been my leading object; and as I have sought it by an

[1] Letter IV. § 40.

attentive study of terrestrial phenomena, so I believe that my travels collectively will be found to contain it[1]."

At no time did De Luc "bring forward the Scriptures as the foundation of geology[2]," as has been erroneously maintained; but he pointed out the remarkable analogies subsisting between them, which have now been admitted by the most eminent naturalists. (See Sect. V.) It would thus appear that in their estimation geological science is sufficiently "furnished with facts" to enable us to discover and exhibit such analogies.

Of this harmonious agreement,—some striking instances of which will be brought together in these introductory observations, in their immediate connection with established points in geology,—*he* could not fail to be a competent judge who had himself extended the limits of physical science, and had proved himself a highly successful experimentalist in various branches of natural philosophy.

Although the Scriptures were not given to man to instruct him in the principles of science, yet it is natural to compare the results of science with the scriptural declarations concerning the creation and deluge, now become the objects of science. Those who discountenance such comparisons, seem to manifest a distrust of the result, which derogates from the divine origin of the Scriptures. The God of Nature, and the God of Revelation, being the same, we need be under no apprehension lest the dictates of Revelation and

[1] Travels in France, &c. vol. ii. p. 392.

[2] See Quart. Rev. October, 1830.

the discoveries of science should not be found to harmonize.

It is important to state, in vindication of the author's claim to original views on the great subject of which he treats, that his "Lettres physiques et morales sur l'Histoire de la Terre et de l'Homme,"—a work, which has essentially contributed to rescue geological science from the disgrace of visionary theories, to which succeeding geologists have been so greatly indebted for many important facts and observations, and which marked the commencement of a new era in the science, —were published as early as 1779,—in which year the first volume only of M. DE SAUSSURE's "Voyages dans les Alpes" had appeared [1].

[1] Of the "Lettres physiques et morales," &c., there is an able analysis in the Monthly Review for 1780, Vol. lxii. p. 527, et seq. and Vol. lxiv. p. 481, et seq. "It bears," says the reviewer, "all the marks of a sagacious and experienced observer, a profound and original thinker, a sound logician, and a good man. It is filled with precious materials relative to the natural world, and the branch of philosophy of which that world is more peculiarly the object; and it exhibits rational, extensive, and noble views of the connection of Nature with its AUTHOR, and with the moral and religious system of the universe······Mr. de Luc, who has hitherto been only known as one of the first natural philosophers of our time, assumes here new aspects, still more interesting to humanity, namely, those of the moralist, the citizen, the friend of man,—who speaks the language of wisdom to the peasant, the artist, the legislator, and the sovereign, and appreciates with sensibility, truth and precision, the genuine sources of human felicity."

It is obvious that those who have considered De Saussure's "Voyages dans les Alpes," as having laid the foundation of sound geology, cannot have perused the important work in question. To the distinguished merits, indeed, of that celebrated naturalist all Europe has borne a just testimony; while few have

SECTION II.

Fundamental point in Geology established by the author.

The following fundamental point in geology has been established by De Luc with undoubted success:

been so well enabled to appreciate, and none more anxious to acknowledge them than our author himself. But the geologist who has given the most detailed and accurate descriptions of various portions of Europe,—of Holland, the banks of the Elbe, the Weser, and the Rhine; of Westphalia, and lower Saxony;—who, by accurate observations at the mouths of great rivers discharging themselves into the sea, has shown that the level of the ocean has not undergone any change since the last great revolution; who was the first to describe the interesting phenomenon of extinct volcanos, &c., has rendered as great services to geology as he who has described the region of the Alps. While further, he who, like De Luc, has been in a great degree successful in connecting existing phenomena with their causes, and has thus established the foundation of the physical history of the earth, has conferred still higher benefits upon science.

The great work in question is full of general views and conclusions, not, perhaps, on the series of formations from the primitive to the tertiary; but respecting other points fully as important, the operations, for instance, of the ancient sea upon its bed—the destruction of the great part of the strata of chalk, and the origin of the flints found in sands, (Lettres physiques, &c. vol. v. p. 116, and pp. 47, 48.); the analogy of marine bodies with the fossils which resemble them,—ancient and modern volcanos,—a physical chronology,—the structure of the mountains of the Hartz, &c. The theory of earthquakes likewise contained in that work is borne out by all the phenomena connected with volcanos. He had there stated, as he himself observes in the first volume of his Travels in France, that as earthquakes are not accompanied with exterior explosions, the fluid which produces them, and which shakes even the mountains,

—not many ages have elapsed since the continental parts of our globe were abandoned by the waters of the ocean.

"When," he says, "we have studied the continents with attention in all their parts, from their centres to their borders; from their greatest elevations to their lowest depths; when we have seen the regularity of the strata composing the whole of their observable mass, and the quantity of the marine bodies contained in those strata, it is impossible not to acknowledge that we are inhabiting an ancient bed of the sea[1]."

But that a comparatively short period of time has elapsed since the retreat of the ocean from our pre-

cannot be any other than "*aqueous vapour.*" He supposed "that the waters which circulate in galleries above those wherein lavas are formed, commonly find free issues; but when, in consequence either of some obstacle in their course, or of some increase in their volume, they rise in these channels, they then meet with crevices through which they penetrate down to the furnaces where the lavas are prepared. Among physical causes, there is no one that possesses a power equal to that which may be exercised by the aqueous vapour produced in these subterranean furnaces, while it subsists with the same degree of density; as is the case so long as it only extends itself along the deep galleries in which the matter of the lavas is formed by a kind of combustion; but when at last this vapour enters higher passages, where it no longer finds an equal degree of heat, it is decomposed, and thus loses its force." In that earliest of the author's works, he had expressed the opinion, that the basalts scattered on our continents are the product of lavas which burst forth at the bottom of the ancient sea. In Vol. IV. pp. 258—260. 472; and Vol. V. pp. 362—369. will be found the proofs that the extinct volcanos on both banks of the Rhine have burnt beneath the waters of the ocean.

[1] Travels in England, vol. ii. p. 927. Letter V. § 6. Lettres sur l'Histoire de la Terre, &c. Vol. v. p. 456. et seq.

sent tracts of lands, is a position which by some naturalists has been contested. Several slow causes of a gradual retreat from its former bed had been imagined; but by continued observations of terrestrial phenomena, the author was enabled to demonstrate, in the above mentioned work, that all such slow causes were purely imaginary.

Geological Chronometers.

The following is the nature of the proofs by which, on the other hand, he was led, in the study of the earth, to infer the recent origin of our continents. If, he says, they are of small antiquity, all the classes of phenomena which indicate a succession, and which appear to date their origin from the existence of the new lands, are to be traced back to the same period; with as much exactness, at least, in respect both to the data and calculations, as regard to the nature of the objects can require[1]. Now, it is from such different classes of phenomena, that he has succeeded in establishing, with a precision of which the subject could scarcely be deemed susceptible, a well defined physical chronology of the earth, by means of what he has termed *natural chronometers*. It is from the documents of nature, and not from those of history, that he has deduced the chronology of our continents, and that of the human race.

From the period of the retreat of the sea from our lands, they have been subjected to a series of opera-

[1] Lettres sur l'Histoire de la Terre, &c. Vol. i. p. 11.

tions which are of such a nature as to leave monuments of their progress from certain points at which it is evident that they must have commenced; their action still continues, and is carried on before our eyes [1]. "Every natural object upon our continents," he says, "is a chronometer; and that, from the same general cause, viz. that every object which was liable to undergo a change, by reason of the state in which it then was, and in consequence of the action of physical or mechanical causes, began at that time to suffer such a change. We are thus supplied with an infallible guide in the history of the earth, through which we are conducted by unquestionable monuments. Wheresoever, by any perceptible cause, some part of our continents has suffered a change since the time at which they emerged from the sea, we can discern what was its particular state at that period; and whilst we are enabled to ascertain the total change, we find portions produced within known times [2]."

The operations of those causes have been ascertained by the enlightened author of the present work with singular ingenuity and success. All their products and effects are capable of measurement; they are absolutely distinct and independent of each other, having nothing in common but the point of their commencement; yet, however different in their nature, they all lead to the same conclusion:—the impossibility of carrying back the origin of our con-

[1] Geol. Travels. Vol. i. § 99.

[2] Abrégé de principes et de faits concernans la Cosmogonie et la Géologie, p. 92. Brunswic, 1803.

tinents to a period more remote than that which the Mosaic chronology has assigned to the deluge.

Various classes of these chronometers are minutely described in the author's "Lettres sur l'Histoire de la Terre et de l'Homme," in the Journal de Physique[1], and in his Travels, as resulting from numerous phenomena;—such as the collection of vegetable earth produced by the decomposition of plants on uncultivated soils—the natural history of peat mosses—the extension of snow and ice on high mountains—the accumulations of fallen materials under the abrupt sides of mountains, and at the foot of steep coasts—the reduction of cliffs into grassy slopes—alluvial lands formed by rivers along their course—maritime new lands, &c.[2] We are here presented with chronometers, all possessing the same conditions; and consisting of effects resulting from known causes, which can have been in operation only since the continents have existed, and of which the progress within known times is indicated by indisputable monuments[3]. More-

[1] See the 26th, 27th, and 28th Letters addressed to M. de la Métherie, tom xli. (part ii.) 1792.

[2] "De Luc, to whom geology is indebted for more numerous facts than have ever been presented to the world, before he brought them forward to our view, is the first philosopher who thought of looking to this habitable world itself for the record of its birth. He has examined numerous physical chronometers, and demonstrated that these agree with revelation." Rev. JOSEPH TOWNSEND's "Character of Moses Established for Veracity as an Historian." Vol. i. p. 398.

By "habitable world" is meant our present continents. It may here be proper to notice, that when De Luc speaks of their *birth*, he adverts to the period when they were abandoned by the sea.

[3] The following geological chronometer is noticed by Mr. R. C. TAYLOR in his interesting geological dissertation on the eastern part of Norfolk. Speaking of the Roman Causeway, supposed to have

over, the completion of several of these effects has been pointed out by the author in a variety of places [1].

For the purpose of here further manifesting the nature of geological chronometers, as traced by De Luc, some of those just mentioned may be selected for remark.

Gravity, and the action of the rains, and other atmospherical causes, have a continual tendency to crumble down and reduce the abrupt sections of mountains, as well in valleys, as towards the plains. The detached fragments are accumulated at their feet, and "rise against them with that kind of slope, which, in fortification, is called a *talus*, being formed by materials rolling down over each other from a certain point;" and preventing the farther demolition of the parts which they thus have covered [2]. The

been made by the Emperor Severus, which extended from Denver to Peterborough, across the Fens of Cambridgeshire, he says: "It was composed of gravel three feet deep and sixty feet broad, but is now covered with moor or peat from three to five feet in thickness. Evidence is thus produced of an increased elevation of surface, and the gradual formation of solid land, either by the deposition of oozy sediment, or by the growth and decay of vegetable substances; and data are supplied, as in the case of the ancient anchors, in the Garienis, for measuring the extent and duration of that process."

[1] Journ. de Physique, tom. xli. (part ii.) pp. 229—239. 1792.

[2] Geol. Travels. I. § 103. "No man," he there remarks, "can travel round mountains, or along their valleys at any height, without having examples of these effects before his eyes. In great mountains, particularly, we see abrupt sections, one above another, under each of which we may observe these *taluses*, composed of the fallen materials, and forming amphitheatres of the greatest beauty, from the vegetation which more or less overspreads them, and from the variety of its products. This aspect is absolutely general; it is

gradual progress of this general operation is clearly discernible by the progress of vegetation[1]. Now, if an antiquity without any assignable limits is to be ascribed to our continents, such operations must long since have been every where terminated, and the surface of the slopes would be found entirely overspread with plants and verdure. But, remarks De Luc, the operation continues, and we observe its different stages, which depend on the original state of each individual part, and on the nature of its strata[2].

the actual form of all mountains, not only in Europe, but in all parts of the world, as may be judged from the views of various countries, which adorn the works of travellers; and it is so generally known as the character of mountains, that we find it to be impressed on the imagination of every landscape painter. What could have produced this form so universally, unless it were one *general original state*, acted on every where by the *same causes?*" See also Letter V. § 35.

[1] These natural processes are minutely described and explained in Letter V. § 45.

[2] "Mouldering cliffs are excellent chronometers. Each has an accumulation of fragments constantly rising against the scarp. This in time will vanish, and instead of cliffs there will be hills, occupied by woods, by pasture, or by tillage." Rev. Joseph Townsend's Vindication of Moses, &c. Vol. i. p. 402.

"To the gradual softening of its slopes, is the valley of Campan indebted for being one of the most delightful retreats of pastoral life: it was once a deep ravine...... but the debris of the summits that command it have raised the bottom of those precipices; the waters have had a constant tendency to level the soil in their course, the process of crumbling down has been continued, rest has succeeded to long convulsions, and vegetation has covered those heaps of ruins now fitted for its reception. The valley of Campan may then be regarded as presenting by anticipation that appearance of repose described by De Luc, who has foreseen what mankind are to expect in regard to the perfectibility of our continents. Such will be all the valleys of the Pyrenees and the Alps, of Caucasus, of Atlas and the Andes." Journ. de Physique, tom. xli. (part ii.) p. 334. 1792.

Further:—It has been rendered evident by De Luc, that the action of the sea[1] has a tendency to efface the original indentations of coasts, by diminishing the promontories, filling up creeks and bays, and reducing cliffs to gentle declivities. These simultaneous operations on the same coasts must have commenced as soon as the ocean retired into its present bed; they continue, and by the effects produced, compared with their measurable progress, necessarily constitute a direct chronometer. Accordingly all the lands formed by the sea upon its shores are every where distinct in their composition from those to which they are joined; they are horizontal from the point of junction to their actual extremity, and continue to increase. Now, from the known progress of these lands, compared with their total extent, it is manifest that the sea cannot have occupied its present bed during a very great number of centuries[2]. Again, at the entrance of lakes[3], the progress of the accumulation of the

[1] Professor JAMESON observes, that "De Luc, in his various works, has estimated this action with a correctness of observation and of reasoning, which is remarkable only, because it has not been adopted by all naturalists." Essay on the Theory of the Earth, translated from the French of CUVIER, p. 449. Fifth edit.

[2] The first establishment of this particular chronometer in geology, is distinctly ascribed to De Luc by DOLOMIEU, in his Mémoire sur la Constitution Physique de l'Egypte: "I have already said, and I here repeat it; to the works of that philosopher it is, I am indebted for that luminous idea." See likewise Dictionnaire des Sciences Naturelles (article *eau*) by M. ALEX. BRONGNIART, where a similar acknowledgment is made.

[3] It is remarked by the Rev. Joseph Townsend, that the great lakes exhibit accretions at the entrance of rivers into them, similar to deltas at the mouths of those which discharge themselves into the sea. "Thus," he says, "it is in the lake of Geneva, as particularly

sediments of rivers affords another striking chronometer of the same kind; and in every such place, the

noticed by De Luc. This forms an excellent chronometer. For had our continents existed myriads of ages before the time assigned by Moses to the deluge, the lake of Geneva had been long since filled with the sediments of its waters, and had become an extensive plain; because not an atom of this sediment either escapes out of the lake, or is deposited at any considerable distance from its entrance into it. The Rhone, at its departure from Geneva, having deposited all its impurities, is perfectly limpid, and although thirty feet deep, does not appear to have the depth of thirty inches." Character of Moses, &c. Vol. i. p. 398.

Speaking of the delta formed by the Rhone, in the lake of Geneva, Mr. J. A. de Luc observes, that "Mr. LYELL is to a certain point correct, when he asserts, in his 'Principles of Geology,' pp. 223, 224. that it was first necessary to ascertain the quantity of matter conveyed by that river into the lake, and to measure the extent of that part of it which is filled up, and its thickness; it is only by exact measurements that we can arrive at positive results. Although I have very frequently visited the spots, I could not state with precision how far our lake has been diminished by the new lands of the Rhone. The breadth and depth of the portion filled up are considerable. Its length may extend to three leagues, and its breadth to one league. At a league's distance from the mouth of the Rhone, the depth of the lake was from 90 to 104 fathoms, or about 600 feet. Much time is necessarily required for such a depth to be filled up by the matter carried down by a river. But although these calculations have not been made, it may nevertheless be justly concluded from the fact of so small a proportion of our lake having been filled up, that a great many ages have not elapsed since the flowing of the Rhone. Although the Rhone deposits its impurities in the lake, it still conveys sedimentary matter to the sea, collected from the tributary rivers of the Arve, the Ain, the Saone, the Isère, the Drome, the Durance, the Ardèche.

"I cannot refrain from observing that Mr. Lyell's arguments too often rest on gratuitous hypotheses. Thus he supposes that the Rhone may have flowed into the lake for thousands of years, without importing any sediment whatever; and states that such would have

dates at which possession was taken of new grounds, and embankments were opposed to the swells of the streams, are ascertained [1].

been the case, if the waters had first passed through a chain of upper lakes, and through the channels of many of its principal feeders. Of the existence in former times of such lakes, there is no proof. The bottom of the valley, indeed, is flat in the vicinity of Martigny, and between that town and Sion; but it was in all probability the waters of the ocean, at the time of its retreat, that levelled the bed of the valley, not the waters of the Rhone. Between Martigny and the lake there is no level ground, except what has been produced by the sediments of the Rhone on entering the lake. In a short memoir written a few years ago on the Alpine valleys which have their beds levelled, I came to the conclusion that such a state was produced by the waters of the ocean which levelled the valleys by the sedimentary matter they conveyed and deposited. The rivers may have afterwards contributed to produce the same effect, but not by filling up lakes. I do not understand the force of Mr. Lyell's argument, when he mentions the channels of many of the principal feeders of the Rhone. Its feeders are all the torrents that come down the lateral valleys or gorges; they flow very rapidly on account of the slope, and they have conveyed gravel, mud, &c. into that river, ever since the retreat of the sea."

In the following passage this chronometer is also admitted by the authors of the "Outlines of the Geology of England and Wales."—"The alluvial tract at the mouth of the Po has been ascertained by observation to have a regular rate of increase in a century; and the line where this tract begins, against what must have been the original coast, is capable of being determined; these data afford, it is obvious, sufficient grounds for calculating the length of time requisite to produce the whole of this alluvial tract." Outlines of the Geology of England and Wales, by Conybeare and Phillips. Introd. p. xxxii.

[1] Speaking of the sedimentary matter which rivers bring down with them to the sea, the author strikingly observes: "This is the true clepsydra of ages, which takes its date from the last revolution; [namely, that which occasioned the interchange of land and sea,] the zero of time is there in a manner fixed by the unchanging level

The fifth Letter in the present collection likewise exhibits a masterly view of the several chronometers with which our continents supply us. Those which are formed by the progress of agriculture, and the various stages of cultivation, will excite peculiar interest, as affording one of the proofs of the small antiquity of the *human race* upon our present lands [1].

of the ocean; and its degrees are marked by the accumulation of the deposits of rivers, as they were by the accumulation of sand in our ancient chronometrical instruments." Lettres sur l'Histoire de la Terre, &c. Vol. v. part ii. p. 497. 1779. See likewise the Fifth Letter of this Volume, § 29.

[1] Adverting to this subject in his Travels in the North of Europe, §. 366, "The countries naturally fertile," says the author, "were the first peopled; and there every trace of progress has long since been lost, as well in their culture, as in the number and manners of their inhabitants. But, as population increased, it extended itself of necessity over those less favourable soils, which, for a long time, had been thought wholly unfit for tillage, and capable only of affording shelter for game, or a meagre pasturage for cattle. It is true that, according to the most ancient monuments among all nations, agriculture, on these continents, is coeval with the human race itself; but at first it consisted only in the use of the plough for the purpose of raising corn, and in the dressing of the vine; by these, in good soils, the increase of population was promoted; but the art of fertilizing soils naturally sterile made very slow advances, and was taught only by experience and necessity. The barren lands, not occupied by forests, appear to have been, for the most part, covered with heath; and it is on these in particular that the progress of agriculture forms a true *chronometer*, by the various stages of fertilization observable on the soils brought into tillage, some much earlier than others; and by the consequent transformation of hamlets into villages, and of villages into towns, still retaining names denoting their small origin, as well as by the increase in the number of hamlets, in proportion as cultivation has extended itself over desert tracts; of this my present travels will contain additional examples."

That our continents have successively emerged from the waters of

In that Letter, §§ 20, 21, he says, "the evident history of the cultivators of our land, comes in as a support to those facts that relate to spontaneous vegetation, to set aside the fabulous pretensions of some nations to antiquity; since it follows equally from both, that our continents themselves can have no higher date than the deluge described by Moses."

the ocean, is an hypothesis which he had already shown in his earliest work to be wholly unsupported by facts. The progress of agriculture, and general observation, supply us with numerous proofs that they have been gradually fertilized, dating from some particular point of time at which they were suddenly abandoned by the sea. Lettres sur l'Histoire de la Terre, &c. Vol. iii. p. 29.

"Mr. Lyell," observes Mr. J. A. de Luc, "speaks much too disparagingly of the natural chronometers of my uncle. He ascribes one to him (p. 301.) which was established by my father, (G. A. de Luc) from the moving sands of the African deserts, which have been driven by the westerly winds over Egypt. But here Mr. L. accuses my uncle of having 'proceeded in his chronological computations on a multitude of gratuitous assumptions, not one of which he had the candour to state explicitly.' He is unable to substantiate his charge by any valid proofs, and De Luc's chronometers have been generally allowed by Dolomieu, Cuvier, Alex. Brongniart, and other geologists. It is a manifest injustice to accuse him of want of candour; no philosopher has ever rendered himself less liable to such an imputation.—Mr. Lyell's explanation, (p. 449.) of the geological fact connected with the three pillars of the temple of Jupiter Serapis, perforated by marine bivalves, (pholades) is the same given by my father, viz. a depression below the level of the sea, and a subsequent elevation." See 'Observations sur les colonnes percées de pholades du temple de Sérapis à Pozzuolo près de Naples; suivies d'une nouvelle remarque sur les volcans,' published in the 'Journal de Physique, Cahier de Frimaire, An VIII.' (Nov. 1799.) My Father's observations and opinions had already been made known by my uncle in his Lettres sur l'Histoire de la Terre, &c. Letter XLI. Tom. ii. p. 291. 1779."

The celebrated naturalists Dolomieu and De Saussure acquiesced in the various proofs thus adduced by De Luc of the recent origin of our continents, and supported them by new facts resulting from their own observations. "I shall defend," says the former, in his Mémoire sur les Pierres Composées et sur les Roches, (Journal de Physique de Paris, tom. xli. Part ii. p. 42. 1792,) "another truth, which appears to me incontestable, and which the works of De Luc have rendered evident to me; a truth of which I see the proof in every page of the history of man, and in all those wherein the phenomena of nature are recorded. With De Luc, I shall say, that the actual state of our continents is not ancient; with him I think that but a short period of time has elapsed, since they were delivered up........to the dominion of man." And De Saussure, in the second volume of the "Voyages dans les Alpes," § 625, speaking of the Glaciers des Bois, in the valley of Chamouni, situated on the opposite side of the central chain, expresses himself as follows:—"The blocks of stone with which the bottom of this glacier is loaded, lead to an important reflection. When we consider the smallness of their number, and recollect that they are deposited at this extremity of the glacier in proportion as the ice melts, we are astonished that there is not a more considerable heap; and this observation, as it agrees with many others which I shall report in succession, may induce us to believe, with De Luc, that the present state of our continents is not so ancient as some philosophers have supposed it to be [1]."

[1] This important truth is also acknowledged, and upon similar grounds, by M. Alex. Brongniart, in his "Traité sur les Terreins

While allowing to Dr. BUCKLAND all the praise which is due to that geologist as a judicious and enlightened observer, it would be an act of great injustice to De Luc, to withhold from him the exclusive merit of having been the first to point out those chronological monuments in the physical history of the earth, afforded by the various operations which are taking place on our continents. Nor can it fail to excite some surprise, that his name should have been passed over in silence by the professor, when deducing the same inferences from these phenomena, and repeating the same observations which had been made with the utmost accuracy and care by that illustrious geologist, upwards of forty-five years before the publication of the "Reliquiæ Diluvianæ." If Professor Buckland

qui composent l'Ecorce du Globe," a work which will be further noticed in the sequel of this Introduction. Speaking of "*humus*, or vegetable earth," he observes, "that its little thickness over the whole globe, and even in places where vegetation is most active, offers one of the most powerful arguments in favour of the slight antiquity of the present state of the earth's surface."

"In the present state of our natural science," says Mr. KENNEDY, "a simple rule of proportion suffices to determine the period at which the last catastrophe of our planet commenced." Lectures on the philosophy of the Mosaic Record of Creation, Vol. ii. p. 210. "It ranks as one of the proudest achievements of geognostical science, that the phenomena of diluvian origin have at length been assigned their chronological relations. The *Christian philosopher* has thus been enabled to elicit from the mysterious symbols of nature, the dates and circumstances of its revolutions, and to add one more link to the adamantine chain of the evidence of his faith." Vol. ii. p. 117.

A more intimate acquaintance with the writings of De Luc, will no doubt induce the pious and erudite Lecturer, to transfer to our author the tribute of praise offered in the last passage to the able naturalist whom he has in view.

deemed it right to mention in honourable terms the observations of Cuvier, much more does it seem to have been incumbent on him not to forget the naturalist who had so successfully preceded the latter in the same researches[1].

[1] In a letter to the editor, Mr. J. A. de Luc remarks,—" In the Reliquiæ Diluvianæ, p. 188, when stating that streams and torrents are incompetent agents for the excavation of valleys and the formation of beds of gravel, Professor Buckland quotes only Dr. KIDD, Mr. GREENOUGH, and Brongniart, in his Natural History of Water. He makes no mention of De Luc, who was the first to prove the incompetence of such agency for those purposes, in all his geological works, and more particularly in his last Travels, published in 1811, 1812, and 1813. See the Table of Geological Facts at the end of Vol. iii. of the Geological Travels on the Coasts of the Baltic, and in England.

" The Professor, p. 189, mentions the new lands formed by the rivers of Holland, lands which never rise above the level of the highest possible land-floods; while the diluvial deposits rise from beneath them, into a chain of hills. Upon this, he speaks of his own observations, which are merely a repetition of those of De Luc, made with the greatest accuracy, and after which, nothing more could be said, or better to the purpose. ' The history of deposits of this kind,' he says, (depositions of mud and silt, forming new lands at the mouths of rivers) ' has been so admirably illustrated in M. Cuvier's Theory of the Earth, and the proofs he advances to show that the period at which they began to be formed, cannot have been exceedingly remote, are so decisive, that referring my readers to him for further information on this subject, I proceed to consider,' &c.

" Without any wish to detract from all that may be ' admirable' in the manner in which Cuvier has traced the history of the new lands, I shall simply ask whether it is equitable thus to pass over the first author who has ever treated this subject—who has not handled it superficially, but profoundly—whose observations are fully sufficient to prove the comparatively short period that has elapsed since the last great revolution—who has extended his observations upon this subject from Holland to the Elbe—who has traced

In regard to that part of the professor's work, in which the interchange of sea and land, at the period of the deluge, is denied by him to have taken place, the editor has been favoured with some observations by Mr. J. A. de Luc, of which the following is the substance:—

The mode, Mr. J. A. de Luc observes, in which the professor conceives the deluge to have taken place, appears inadmissible. He does not inform us by what means the ocean was expelled from its bed, so as to occasion the deluge, nor what causes determined the retreat of the waters into their former basin. In maintaining the fact of an universal deluge which should have reached the summits of the highest mountains of the *present* continents, he takes no account of the fate of the plants and animals which must necessarily have all perished. He does not inform us how the earth, after this revolution, was

out the history of the new lands of the Meuse, the Rhine, the Issel, the Ems, the Weser, the Oste, and the Elbe—who has distinctly marked out the line where the alluvial soil comes into contact with the continental soil, [called in Germany *geest;*] who has given a detailed history of the first settlements on those new lands, as they were gradually forming. The authors who have followed or copied De Luc, have in fact done little more than confirm his inferences or results by similar observations carried on at the mouths of other rivers, such as the Nile, the Po, the Adige, the Garonne.

"The facts IV. IX. adduced in pp. 226—228 of the Reliquiæ Diluvianæ, are the chronometers of De Luc." See Geol. Travels, 1813. Vol. ii. §§ 821, 823, where the author speaks of the gravels of the banks of the Elbe, the same as those which are found in the soil of the whole country, and even on the hills. See also the Table of Geological Facts annexed to the Travels in England, Vol. iii. p. 547. et seq.; "General Considerations on the Phenomena which prove the small antiquity of our Continents;" and a similar table at the end of Vol. ii. of the Travels in France, &c. p. 430. et seq.

re-peopled with organized beings, since those which now inhabit the earth are not the descendants of its antediluvian inhabitants, with the exception of domestic animals, and the seeds of plants preserved in the ark by Noah. Neither does he at all advert to the influence which the atmosphere must have exercised in connection with the phenomena of the deluge. It would appear, that at that period a great portion of the atmosphere was resolved into water; and it is to those superior waters that must be ascribed a part of the devastations produced on the earth's surface.—Professor Buckland cannot readily get over the argument drawn from the absence of all human remains from among the fossil bones of terrestrial antediluvian animals; an argument confirmed by Cuvier in his "Recherches sur les Ossemens Fossiles," (1825), and which proves that the lands now occupied by the human race, are not the same with those which it inhabited before the deluge: and that these last are now beneath the waters of the ocean. This argument bears with it such weight, that it is not easily conceivable how the professor could pass it over so slightly[1]. He ascribes a great deal too much to the action of the waters of the flood. How can he imagine that an inundation, sudden, simultaneous, universal, and transient, such as he describes, can have excavated the transversal valleys? It is not a

[1] Letter VI. § 31. "The multiplication of those large quadrupeds, whose bones are found in such vast numbers in our soil," Mr. J. A. de Luc elsewhere observes, "would alone be sufficient to prove that man did not exist upon the same lands, were it not moreover known that in the strata which enclose the remains of the former, no human reliquiæ have ever been discovered." See Bibliothèque Universelle, (Sciences et Arts), Vol. xix. p. 132.

simple passage of waters that can have produced such astonishing effects. A cause is wanting which had been already considered necessary by the late Mr. ESCHER, of Zurich, who has so carefully observed the Alps. Let us advert to this geologist's assertions respecting the transversal valleys of that chain. "If those valleys," he says, "and the mountains which border them, are considered with attention, the following remarks, in general, will occur. Those valleys intersect the longitudinal chains, and the longitudinal valleys at angles more or less obtuse, frequently even at right angles; and the masses which are on each side of those intersections, exactly correspond in the direction and inclination of their strata; insomuch that the valleys exhibit the appearance of breaches made, by some subsequent cause, in the strata, originally continuous, of the great chains. The intermediate mass which previously occupied the vacancy, was destroyed and carried away, at a time when the mountains were already consolidated in the manner they now actually are. Nevertheless, it by no means follows from hence that the transversal valleys have been gradually excavated by our present currents. Here causes much more powerful have been at work; for the transversal valleys, at their outlet from the Alps, are very deeply intersected, as is more especially rendered evident by the lakes which still exist, and which are found at the opening of many transversal valleys." Mr. Escher is of opinion that the fractures which produced the transversal valleys of Switzerland, were occasioned by the violent passage of the waters which originally filled the highest longitudinal valleys[1].

[1] Mr. J. A. de Luc assigns another cause to the opening of the transversal valleys. See Letter I. § 21, (note.)

He considers that revolution as identical with that which swept from the Alps those innumerable fragments of rocks now observable, and which scattered them over the deep valleys, as well as on the sides of the chain of Jura opposite the Alps. He accounts for the disappearance of the rocky masses which once filled up the gaps by which the transversal valleys intersect the chains, by directing the attention to the enormous heaps of rolled pebbles which are found in all the longitudinal valleys, and along the whole line of the foot of the Alps; to which must be added the materials which fill up all the depths of the great valley situated between the Alps and the Jura. "Some of the valleys of the Alps," says Dolomieu, "have been excavated in the heart of those mountains by an abrasion as violent as it was active, a circumstance indicated by the correspondence of the banks in the sides in perspective, and which is ascertained, with regard to some of the valleys, descending from Mont Rose, by metallic veins which preserve their direction by appearing in the mountains opposite, notwithstanding the great solution of continuity." It is not assuredly the transient waters of Dr. Buckland's deluge which have produced those abrasions, nor which have detached the granite blocks from the needles of Chamouni.

If mountains such as the Mont Blanc, have been formed by elevation, or by what De Saussure terms *refoulement*[1], as several able geologists imagine, it is not necessary to raise the waters of the deluge to the height of the loftiest mountains, in order to explain the transportation of the granite blocks.

[1] See Letter I. § 21, (note.)

It is by no means probable that at the epoch of the deluge, the surface of the sea attained the high summits of the Alps [1], and in particular the basis of the needles of Chamouni, where we only just begin to find the chloritic granite, similar to that of which the blocks which lie on Mont Salève are composed. On the contrary, there are phenomena which indicate that at the period of the last retreat of the sea, its level was but little elevated. This would appear from those accumulations of marine exuviæ belonging to the mollusca, which now lives only on the sea-coast, and in shallows; such are the accumulations, constituting the beds of fossil shells of Piedmont, the States of Parma, and those in the vicinity of Paris. When these animals lived, the waters of the sea could not be of very great depth upon the plains of Europe; all the chains of mountains, and their upper valleys, were above the level of the sea. The fragments of petrified wood, and the bones of the large quadrupeds, such as the elephant and the rhinoceros, found with the beds of shells in Piedmont, in the States of Parma, and in the Val d'Arno, evidently show that there existed dry lands, in the neighbourhood of the sea where those animals lived to which the shells belonged; and such lands could not be other than the valleys of the Alps, and those of the Appennines. We may, therefore, suppose that the sea was at that period raised only from two to three hundred toises above its actual level; its waters were consequently very far from reaching the basis of the needles of

[1] De Luc is of opinion that the Alps were islands in the ancient sea. Journ. de Physique, tom. xli. (part ii.) p. 221. et seq.

Chamouni, whose height above the level of the ocean is from twelve to thirteen hundred toises—or even the basis of the needles in the sea of ice, which is less elevated.

In reference, also, to the adoption, by the Rev. G. S. FABER, of Dr. Buckland's opinion, that the tracts of land which we now inhabit are the same as the antediluvian continents, Mr. J. A. de Luc makes the following remarks:—"This opinion is not only subverted by the argument deduced from the total absence of human fossils from our strata, but there exist undeniable proofs of a long continuance of the ocean upon extensive portions of the present continents, immediately preceding the retreat of the waters from their surface[1]. It is in vain that Mr. Faber seeks the site of Paradise: the state of the earth is altogether changed. Mr. F. observes, in his Origin of Pagan Idolatry, that the antediluvian mountains 'must have sunk very deep in order to lay bare such mountains as the Andes.' Granting, however, that the Andes should always have had the height which they now have, a circumstance which admits of a doubt, it is not necessary to suppose that the waters of the ocean rose to their summit previously to the flood; they might have stood at a much lower level. Mr. Faber does not seem perfectly to understand the opinion of De Luc, when he says

[1] See Mr. J. A. de Luc's interesting Memoir in Vol. xix. of the Bibl. Univ. (Sciences et Arts) 1822, pp. 120—132, entitled, "Considérations sur le gisement des os fossiles d'Eléphans." Similar conclusions from the phenomena were formed by M. Alex. Brongniart, as will appear from a passage cited at the end of the Vth Section of this Introduction.

that the olive-leaf could not have been plucked off by the dove from a tree that floated at the surface of the waters. De Luc conceives that the olive-leaf was plucked off from a tree which grew on an island that had not been submerged[1]. Mr. Faber is in error when he thinks that a continuance of a hundred and fifty days at the bottom of the waters would not have destroyed the olive-trees; ten or fifteen days would have sufficed for that purpose. Besides, the violent motion of the waters would have suffered nothing to subsist at the surface of the earth; all vegetation would have been destroyed, or swept away." In the general correctness of these observations, the editor cannot but concur.

Long Residence of the Sea upon extensive portions of our Continents immediately before the last Revolution.

That the sea rested for a considerable period of time on many portions of our present lands, previously to its retreat into the bed which it now occupies, has been satisfactorily shown by De Luc. It would appear from his repeated observations in various parts of our continents, that numerous and very extensive strata of quartzose sand, together with beds of clay, marl, and other materials were chymically precipitated from the waters of the sea, at a period immediately preceding the great revolution; and that it is by a continuation of its last precipitation, that we find its new bed covered with a great abundance of sand[2].

[1] Letter VI. § 18.

[2] See Letter II. § 16. IV. § 32. In the 589th § of Vol. ii. of the Travels in France, &c., the author adduces the testimony of De

Many of those strata which abound with marine bodies, were evidently formed in the very places where they are now deposited, and indicate a long residence of the sea [1]. In Siberia, for example, fossil bones are frequently discovered in or beneath strata filled with shells. Thus, at a short distance from the river Iset, which discharges itself into the Tobol, there have been found, in a sandy bluish clay, the bones of elephants black at the exterior, and in a decayed state, together with shark's teeth; that bed of clay was covered by eight different strata of a marly yellow clay, sand, &c., of which the four lowest were micaceous. Mr. J. A. de Luc quotes the authority of Professor Pallas for this particular fact; he observes that the operations of the sea must have been of long continuance on that spot, after the elephant bones and the shark's teeth had been buried in the blue clay; and states his opinion that a great part of

Saussure, in confirmation of his opinion, that the sand extended in strata over vast tracts of country in different parts of Europe, and similar to that on the bed of the sea, is the product of the latest precipitations in the ancient ocean. "It was not owing to incursions of the sea upon our continents, that it has covered them with so much sand: it deposited the sand, stratum by stratum, during its abode upon them." Letter V. § 9.

[1] "We do not perceive in these loose strata," says the author, "any sign of violent agitation in the water that produced them; they have been formed, like all the other strata, by deposits made at the bottom of a tranquil liquid, and all the extraneous bodies which they contain, were there enclosed," &c. Letter I. § 18. "I have seen bones of elephants taken from several spots which I have myself observed; the soil was composed of regular strata of different species, lying one over another; and thus plainly denoting, as well as some of which I am going more particularly to speak, that the sea was *calm* during their formation." Elem. Treat. § 325.

those bones must have been buried beneath the waters of the ocean, a long time previously to the last revolution [1]. Mr. PARKINSON, in like manner, considers that the widely extended beds of sand and gravel so commonly occurring, with sandy clay, sometimes intermixed and sometimes interposed, were slowly deposited by the sea. Geol. Transact. Vol. I. pp. 327, 341.

It is further to be remarked, that those beds, altogether extraneous to the stony strata on which they had been formed beneath the waters of the ocean, have suffered the same ruptures, dislocations, and partial subsidences, as the stony strata [2].

[1] See Mr. J. A. de Luc's Memoir, noticed above, Vol. xix. of the Bibl. Univ.; and the second part, in the same volume, p. 260, et seq. In that Dissertation will be found several other instances, indicating a long residence of the waters of the ocean upon extensive portions of our present lands, antecedently to its last retreat. See also Letter I. § 15, et seq. and Letter IV. § 6. of this work; and Lettres sur l'Histoire de la Terre, &c. Vol. iii. p. 25; v. pp. 20, 356, 357.

In regard to the gravels which are found intermixed with the beds in question, those of flint, according to our author, proceed from the strata of chalk which were dissolved while still covered by the ancient sea, while those which are fragments of stony strata, chiefly primordial, originate in the revolutions which the bottom of the sea was so frequently undergoing. Mr. J. A. de Luc is of opinion that much of the gravel contained in the superficial soil, and which is composed of fragments of stony strata, was produced by the currents of the sea when it changed its bed, that is to say, at the period of the last revolution which the earth has undergone. See note, Letter V. § 9.

[2] See Travels in France, Vol. I. §§ 138, 311. II. §§ 601, 644, 753, 809. Geol. Travels, Vol. I. §§ 137, 298, 314, 321, 378, 380. Vol. III. § 1007. "I have seen," says the author, "in Germany, in Italy, in France, in England, sandy strata containing marine

Referring, in his remarks on KIRWAN's Geological Essays, to the vast accumulations of shells found in loose and superficial soils, "these shells," says De Luc, "are found in regular strata of marl, argil, and different kinds of sand. In some places, those strata continue the same to the greatest depth we can reach; in others, their nature changes as we penetrate the soil; and then it most commonly happens that, after having met with a certain *family* of *shells* in a particular class of strata, we find different families in those either above or below, in the same manner as we observe the families to change in the *stony strata*, where they form whole mountains. Lastly, the loose

bodies, fractured and inclined together with the stony strata which they cover, whose sections are seen beneath them in spots where a subsidence has taken place on one of the sides of the fracture, and sometimes opposite the *great subsidence*, namely, in the cliffs on the sea-coast." Abrégé de Principes et de Faits, &c., p. 86.

Mr. J. A. de Luc, the younger, speaking of the vertical strata in Alum Bay, in the Isle of Wight, says, "I observed them in the year 1797; they are extremely numerous, and I was much struck by them. Among those strata of marl and clay, there was a bed of flinty nodules in a vertical position, as well as all the strata on the right and left........Those vertical strata extend across the island from west to east; here then we have a striking instance of argillaceous strata, which have participated in the catastrophes of the chalk strata beneath; it is a very important phenomenon, which serves at the same time to prove that *the British channel was formed by subsidence*, and that it is thus the coasts of France were separated from those of England. For a detailed account of Mr. J. A. de Luc's observations in Alum Bay, see Geol. Travels, Vol. II. § 600. A remarkable instance of the phenomenon in question was observed by that able geologist, in 1817, in Piedmont, in the neighbourhood of Annone, between Asti and Alexandria. Bibl. Univ. (Sc. et Arts) Vol. XIX. p. 121. note.

strata, which are always parallel to each other, are in various places fractured, and highly inclined, as well as the stony strata which they cover."

From these facts De Luc deduced the following important inferences:—that while these shells directly prove our continents to have been formerly covered by the sea, it is no less evident that they could not have been deposited by the waters of the deluge; for, in that case, the utmost confusion would prevail throughout all the loose substances on the surface of our soils;—secondly, that these regularly disposed strata were produced from the last precipitations which took place in the sea, when marine animals existed at its bottom;—and, thirdly, that the sea retired from our continents, by changing its bed [1].

Some links of connection which subsist between the facts in geology that have here been noticed, and the Mosaic account of the deluge, will now be pointed out.

SECTION III.

Connection between the Mosaic narrative of the Deluge and Geological Phenomena.

The phenomena of the earth are in essential agreement with the prediction of the flood to Noah, purporting that all the inhabited parts of the globe should be destroyed. "And God said unto Noah, the end of all flesh is come before me; for the earth is filled

[1] Element. Treat. § 326. Letter V. § 8.

with violence through them: and behold, I will destroy them *with the earth.*"

The author had attached the utmost importance to the ascertaining of the precise sense, in the original, of God's sentence pronounced against mankind. He addressed himself to several Hebrew scholars of great eminence, and without acquainting them with his object, he requested the strictly literal translation of the words. All the renderings given him agreed in the sense of our translation, but expressed with greater force, as warranted by the original; and Professor MICHAELIS, of Göttingen, celebrated for his profound knowledge of the Oriental languages, sanctioned the translation thus obtained, having subsequently in his German version rendered the passage as follows:—"Behold, I will destroy them, and the earth with them." There is then no ambiguity in the sense of these truly important words. Now geology, observes De Luc, shows the reality of the deluge as occasioned by the destruction of an ancient land, and the formation of a new one[1]. On the supposition of the reality of the flood, merely, he says,—without any revelation

[1] Lettres sur l'Histoire de la Terre, &c. Vol. v. part ii. p. 648. Consonantly to this fact, Josephus (Antiq. l. i. 3, 2.) writes εἰς θάλασσαν τὴν ἤπειρον μετέβαλε, with which we may compare the force of ἀπώλετο in 2 Pet. iii. 6., as connected with ὁ τότε κόσμος.

The author of "Conversations on Geology," has, it will be seen, fallen into two considerable errors; first, when asserting, p. 313, that "it was never imagined" before "Mr. GRANVILLE PENN's view of the event, that the former antediluvian land was now the bed of the ocean, and our land its former channel;" and, secondly, when he says, p. 311, that "all previous geologists" (previous to Mr. Granville Penn) "have overlooked the words 'together with the earth.'"

to Moses,—Noah and his family, enclosed in the ark during the revolution of the globe which produced the deluge, and simply witnesses of certain effects, could not be able to ascertain its cause, nor consequently have transmitted it to their posterity. And if, in order to ensure attention and deference, they had been induced to add the fiction of a revelation, they would never have invented these words, which, undesignedly, but pointedly, indicate the cause of the catastrophe. The same expressions do not again occur in the narrative of Moses; nothing is found to relate to them, excepting through connections supplied by natural history, and the history of mankind [1]; without such aids those connections are not perceived in his plain and unostentatious recital, and even the Jews did not understand them. Moses, without any comment, related what he was commanded to say. From this whole view of the subject, the certain idea of a revelation will arise: for Moses was not a naturalist; the book of Genesis is not a system of cosmogony, a generalization of phenomena observed and ascribed to certain causes, nor had mankind yet applied themselves to the investigation of terrestrial phenomena. This we know from the vestiges which still remain of the knowledge of the most ancient nations [2]. Moses states to the Israelites, that he was entrusted with a special mission from God, for the purpose of announcing anew to mankind the origin of the universe, and from what period of time they had inhabited the earth, as well as to deliver to them a code of Divine laws.

[1] See Letter VI. of this volume.

[2] Lettres sur l'Histoire de la Terre, &c. Vol. v. p. 649.

The Jews had *signs* of his mission, and they believed in him. We have no longer those signs; and hence the necessity of researches on our part [1]. Among the events recorded in his narrative, all those that are circumstantially described, are of a nature to have left traces behind them upon the globe. Now if such traces are discoverable to us by natural history, and the history of man, the whole narration is verified by the only means by which we are enabled to ascertain the truth in subjects of this kind. The fact which De Luc has chiefly chosen, as standing instead of *signs*, is the deluge, and all its consequences; and here the first object which arrested his attention, was the Divine denunciation as expressed in those remarkable words, "behold, I will destroy them, and the earth with them."

"We see," he observes, "that the term earth, does not here signify the terrestrial globe, but the land inhabited by man [2]. It was, therefore, the destruction

[1] Lettres sur l'Histoire de la Terre, &c. Vol. v. p. 647.

[2] Such was likewise the opinion of ISAAC VOSSIUS, as given in his Sacred Chronology; an opinion also adopted by Father MABILLON, who, in the estimation of BOSSUET, was the most pious and learned theologian in France. In 1685, Vossius's work was submitted to the Congregation of the Index, *i. e.* the assembly of cardinals and theologians, to whom was committed the censorship of books. Mabillon was at that time at Rome, and was invited by Cardinal Cazanate to the meeting of the congregation held for the purpose of investigating the charge against Vossius. Nine cardinals were present. Mabillon defended Vossius; he showed, in common with other divines, that the expression, "the whole earth" is not always in scripture language to be rigorously taken, and often signifies only a great part of the world; and more particularly urged that the essential point to be admitted was acknowledged by Vossius,

of those continental parts that was foretold to Noah. Now geology, as I have explained in my former Letter, proves, that at a period corresponding with that assigned to the deluge, there were ancient lands which sank; and as the sea rushed over them to occupy their place, all the organized beings necessarily perished. Thus geology, a science but very lately advanced so far as to explain to us the real history of the globe, comes in, as an evidence, that, at this very period, the human race was destroyed[1]." "If his history had been a fable," the author further remarks, "Moses might well have been expected to show as much imagination, as those painters who, from false ideas of the deluge, have drawn pictures in which men are represented as crowding to the tops of eminences, and flying from rock to rock to escape the waters. Moses

namely, that all mankind, with the exception of Noah and his family, perished in the flood. He spoke with so much erudition and judgment, says the author of his life, that the cardinals acquiesced in his sentiments, and all thoughts of censuring the opinion of Vossius were relinquished. See the Preface to the Paris edition of the following Letters.

"Consentiunt quidem omnes," says LE CLERC in his Commentaries on Genesis, "diluvium eatenùs universale fuisse, quatenùs totum orbem habitatum oppressit, universumque humanum genus, exemptâ Noachi familiâ, eo interiit. At alii volunt totum telluris globum aquis obrutum fuisse, quod alii negant." He then proceeds to state with great impartiality the arguments that have been adduced on each side the question. "It is evident," observes Bishop STILLINGFLEET, "that the flood was universal as to mankind; but from thence follows no necessity at all of asserting the universality of it as to the globe of the earth, unless it be sufficiently proved that the whole earth was peopled before the flood." Orig. Sac. Book iii. ch. 4.

[1] Letter VI. § 6.

then, representing to himself Mount Ararat, as covered with the dead bodies of the inhabitants of the country who had there sought refuge, would have substituted poetry for painting, and we should have had an elegy in the place of those fantastic pictures. But he is silent upon the subject, because he was writing the true history of Noah and his family, who, landing on an *island* of the ancient sea during its retreat, found there no human remains [1].

Thus the absence of human fossil remains from our strata, constitutes another of the many connecting links between the scriptural narrative of the deluge, and the facts and observations of every kind with which we are furnished by geology [2].

These undesigned and unexpected coincidences, coupled with the fact established by the various classes

[1] Letter VI. § 30.

[2] The human remains that have been recently found in the caverns of Bise, near Narbonne, and other spots, together with fragments of earthen vases, and other works of art, are, in the opinion of Mr. J. A. de Luc, jun. and other naturalists, plainly post-diluvian, and their presence may be accounted for by accidental circumstances. He considers that M. MARCEL DE SERRES ventures too far, when he asserts that human remains are *incontestably* intermixed, and are found in the same geological circumstances with certain species of terrestrial mammiferæ hitherto considered as antediluvian. "The occurrence of pottery," says an able writer in the Edinburgh Review, Oct. 1830, "and of the bones and shells of animals still existing, would lead to the notion that these caverns may have been inhabited at a very remote period, but still after the period of the deluge, by some wild animals of the country; or that some solitary human beings may have taken refuge there, and that afterwards the caverns may have been filled with mud by some subsequent and partial deluge."

of natural chronometers, that the antiquity of our continents is not greater than the Mosaic chronology from the deluge ascribes to them, thus afford us a powerful evidence of the inspiration of the sacred writer [1].

SECTION IV.

Two Periods in the History of the Earth.

The study of terrestrial phenomena, says De Luc, enables us to discern and distinguish *two separate periods* in the history of the earth [2]; one prior, the other posterior, to the epoch at which our continents

[1] In the sixth Letter of the present collection, and in the second part of the fifth volume of the " Lettres sur l'Histoire de la Terre," &c. the coincidences in question are very fully considered.

[2] Letter V. § 11. Journ. de Physique, tom. xxxix. (Part ii.) p. 333. 1791. Geol. Travels in France, Vol. ii. p. 375. The *Saturnian*, or antediluvian, and the *Jovian*, or post-diluvian, periods, established by M. Alex. Brongniart, in his classical work, entitled, "Tableau des Terrains qui composent l'écorce du globe," (1829), bear the closest analogy to the two great periods of which an account is given in the text; the distinction indeed was evidently suggested to that able naturalist by the works of our author. The Jovian period, according to M. Brongniart, " includes all terrestrial phenomena that are beyond doubt posterior to the structure and form of our continents, *i. e.* every thing that may have been operated at the earth's surface, without the necessity of having recourse for its explanation to powerful causes, the action of which is no where observable, dating from historical times ······ The Saturnian period comprehends all the geological phenomena, the existence of which cannot be accounted for without calling in the aid of forces which are no longer in action." The most important of those phenomena are enumerated in pp. 63, 64. of his work.

began to exist. To such a distinction we are led by the discovery that the part of the globe which is at present inhabited by man, was once the bed of the sea; for the first period must evidently have been that of the continuance of the globe in this first state; and the second must have begun at the epoch when the bed of the ancient sea became dry land. This last period the author calls the *modern history* of the earth,—in which we have a fixed chronology, and which has already been here brought under consideration:—the former he designates by the appellation of its *ancient history*, which comprises that series of geological events in which we discern only a succession of subordinate periods, without any determination of time [1].

It is to the want of discriminating between these two periods, and between the phenomena separately assignable to each, that the author ascribes the errors of the earliest geologists. They had supposed that our continents, since they have existed as such, have been the theatre of certain operations, which are now demonstrated to have taken place on the bed of the sea; and as this mistake rendered it impossible to attribute these operations to any other causes than those known to be at present acting on the surface of the globe, it has hence been found necessary to allow to the action of these causes a time without any determinate limit; because it cannot be shown that, within a known period, they have produced any similar effect [2]. Of this De Luc adduces as an ex-

[1] Letter V. § 11. Travels in France, &c. Vol. ii. p. 375. Lettres sur l'Histoire de la Terre, &c., Vol. v., Part ii. p. 488.

[2] Travels in France, Vol. ii. p. 376.

ample, "the supposed excavation of valleys by the action of running waters; an operation which would require a time absolutely illimitable, since no actual progress in it can possibly be pointed out[1]." He has, however, on the contrary, made it appear that streams, far from having excavated their beds, have in a variety of places raised them to a higher level than they originally possessed; and has proved that the cavities of the pools and lakes which still exist along the courses of so many rivers, must have been filled up, if the valleys in which those rivers flow had actually been hollowed out by them[2].

[1] Travels in France, Vol. ii. p. 376. See also De Luc's "Geological Travels," Vol. iii. p. 520—528. "Table of Geological facts." In that volume the author combats the error of Prof. Playfair, "in his not allowing for any other agents in the production of valleys, than those which, since the continents have existed, have exercised their action in them." p. 372, et seq.

Professor SEDGWICK is of opinion that the deep gorges and river channels in the high regions of Auvergne, were excavated solely by the attrition of the rivers which still flow through them. Dolomieu, in 1798, had combated this opinion in the Journal des Mines, observing that the valleys of Auvergne could have been hollowed out only by an extraordinary force which is now no longer in action; for it is not by causes now in operation that nature could have produced such excavations. The rills of water which run in the valleys of those districts could not have excavated the mass of a granitic rock, frequently extremely hard, to the depth of six hundred feet, and including a breadth sometimes of half a league, leaving lateral embankments nearly similar to the walls of a rampart.

[2] Travels in France, &c., Vol. ii. §§ 498, 562. "Dr. Hutton's assertion," observes Mr. J. A. de Luc, "'that on our continents there is no spot on which a river may not formerly have run,' is without any foundation; there are extensive tracts of country in Europe which have never been watered by streams. In England, for instance, no river has at any period ever flowed over Hampstead,

But by an attentive study of our continents, it is possible, according to the author, to discover the effects of causes which have been in action on the bed of the sea, antecedently to its retreat, but which have since ceased to operate[1]. By the same enquiry

Highgate, Shooter's Hill, Black Heath, Epping Forest, and yet those hills are covered with water-worn flint-gravel. The channels of rivers having been produced by antecedent catastrophes, were already prepared to receive and collect their waters, and since the retreat of the sea from our continents, the rivers have deviated very little from their original beds. Most of the pebbles occurring so abundantly in the beds of rivers, have not been brought down by them; they were found in the country, and are identical with those still scattered over the neighbouring hills, where no river has ever flowed. But Mr. Lyell asserts, p. 70, 'that De Luc generally reasoned against Dr. Hutton, as if the latter had said, that the existing rivers flowing *at their present levels*, had caused the excavation of valleys.' If Mr. Lyell had quoted De Luc's own words, the reader would have seen that my uncle made no such supposition as Mr. Lyell ascribes to him."

[1] The author states in his Elementary Treatise, that in the course of their geological career, his brother and himself came to a first conclusion, which thenceforth was their guide, and which he always considered as the true introduction into the field of geology. "We saw," he says, "that an essential distinction was to be made among the various phenomena which the surface of the earth exhibits, with respect to their causes; determining in regard to each of them whether the causes which have produced it are still in action, or have, at some epoch, ceased to act. If this discrimination be possible, it evidently becomes a first guide in the research of causes, which will prevent many errors. Now, when we had fully convinced ourselves that this distinction was pointed out by the phenomena themselves, we clearly saw, on studying the theories of the earth then known, that the principal source of the errors, which had been detected in them by subsequent observation, was the confounding of the periods in which certain effects had been produced. For, by attributing to causes which were seen in action, such effects as they were inca-

we may ascertain the cause which, in particular, produced the retreat of the waters from the surface of

pable of ever producing, an impenetrable veil was thrown over past causes; since these can be discovered only by their real effects, more surely to be ascertained when separated from those produced by causes, which are still operating, and producing such effects, as may be discerned to belong to them. Continuing our observations with this object in view, we came at length to a conviction that the production of the mass of our continents, in regard both to their composition and general form, as well as their existence above the level of the sea, should be ascribed to causes no longer in action on our globe; and that the whole of the effects of existing causes had been limited to the modification of this original state. Insomuch that the first study requisite to the investigation of the past history of the earth, was that of the action of causes now in operation, that thus, by their being every where determined, our continents might be traced back to their original state." Pp. 36, 37.

Alex. Brongniart, as has already been stated, and Cuvier [See Vth sect. of this Introduction] concur in recognising the important distinction here made between the causes which have ceased to act, and those which are still operating. This distinction is denied, upon insufficient grounds, by Mr. Lyell, in his "Principles of Geology." Valuable remarks on this subject, occur in a series of Letters by the Rev. W. Conybeare, inserted in the New Philosophical Magazine, 1830, and continued in the present year.

"It would appear," says Mr. J. A. de Luc, jun., "that Mr. Lyell would bring back geologists to the opinion of Hutton and Playfair, that existing causes are the same with those that have operated in ancient times—an assumption which is inadmissible—and that such causes are sufficient to explain all the phenomena. His theory is the same with that of Prof. Bertrand of Geneva, respecting successive renewals of continents, and successive deluges. It is somewhat surprising that such systems should be revived.—One would imagine that Mr. L. is desirous of indirectly combating De Luc, who showed that there had been a commencement to terrestrial phenomena, and that the commencement was the creation of light."—[See the sequel of the present section.]

Some sound reasoning in refutation of Mr. Lyell's doctrine, that

our continents; and may gain also a general knowledge of the physical events which succeeded each

there are no traces of any beginning to the series of changes and productions that have occurred at the surface of the globe, or of any variation in its present agencies, will be found in the Quart. Rev. for October 1830. The writer, in opposition to this doctrine, justly maintains, that all analogy is in favour of inferring that the succession of events which we perceive on the earth's surface has *not* been going on from all eternity, and that the contrary assumption is decidedly more unphilosophical. He illustrates his argument by a direct fact. "The peculiar spheroidal form of the globe is precisely such as would be assumed by a fluid body possessing its actual rotatory motion; a strong and almost demonstrative argument, that its whole surface was once fluid to a very considerable depth, and therefore under totally different circumstances from the present." "The early schistose rocks, gneiss and mica-slate," he further observes, "do not appear to be any where produced in the present circumstances of the globe."

These remarks, it will be seen, are strictly conformable to the views of the author. The latter, from observations of his own and the whole assemblage of facts, entirely concurs in opinion with Dolomieu, that "there is no operation now taking place in the sea, that bears the slightest analogy to those productions of mineral substances in strata, which took place formerly on our globe." Letter III. § 13. In his "Correspondance entre le Dr. TELLER et J. A. de Luc," p. 132, our Author likewise maintains that the formation of strata continued until the time that the sea changed its bed, but that from the period of its residence in its present bed, the precipitations have ceased, *their causes being exhausted.*

"Mr. Lyell," writes Mr. J. A. de Luc, jun., "has dwelt on the effects of volcanos, with a view to show that the same operations are still in action which took place in remote ages. But let him point out volcanos formed in the present day, similar to Etna, and to the Peak of Teneriffe,—to those of Peru, of Chili, of Kamtschatka, &c. He will certainly be unable to do this. It is, therefore, reasonable to maintain that in the earliest periods of volcanic eruptions, these were beyond comparison more considerable than they are at the present day. The same observation holds good likewise with regard to earthquakes."

other upon the globe before the great epoch whence the present abode of mankind derives its date. And by determining, as we thus may, the precise state of the continents, when they were abandoned by the sea, we attain what may be considered as a central point in geology, having reference to both the present and past periods of time above noticed.

In the following Letters the certain and well determined effects of past causes are traced out in minute detail; and the author has a just claim to be considered as the first philosopher who, owing to the deep researches that have been made in terrestrial physics, and more particularly in mineralogical chymistry,—researches which he has himself greatly advanced,—has given a connected view of their general causes. Thus he has pointed out the cause of the successive differences which we observe in the substances of which our strata are composed, together with the origin of these substances. He has thrown great light on the difficult problem presented by the intermixture, in some of our strata, of marine animals with the remains of terrestrial animals and vegetables. He has explained the cause of the disordered state of the strata, and has satisfactorily shown why their ruinous fragments are now found above the level of the sea.

The formation of mineral strata, successively differing in their series and respective species, constituted, he says, the first great effect of those causes at present no longer in action. Now the processes and progressive operations which such formation of necessity implies, must have required a very considerable length of time.

De Luc's assumption, in common with some com-

mentators, that the "six days" of the sacred historian were indefinite periods of time, is well known; and some of the reasons on which his opinion is grounded, are adverted to in the third Letter of this collection, § 1. A further development of that opinion will here be given from works of the author little known in this country, and some corroborating observations will be subjoined, tending to show that those operations were effected, not in solar days, but in periods of indeterminate length. But previously it may be proper to exhibit a brief view of some of the operations considered by him as having taken place during this first period of the history of the earth; inasmuch as not only it will thus be made more distinctly to appear what a vast time these operations must have required, but because from passages which will be adduced from the Preliminary Discourse to the "Recherches sur les Ossemens Fossiles" of Baron Cuvier, the striking coincidence in several of the results of the researches of those two eminent geologists will be rendered apparent.

Summary view of a series of Geological Events which have taken place in periods of indefinite length.

The epoch from which the author begins to trace the principal physical events which have happened upon our globe, is not an arbitrary one, but an epoch rendered evident to us by geological phenomena. The production of the mineral strata having been followed up by an uninterrupted series of other effects, which, though tending towards an end, is not yet terminated,

a certain original period in the history of the earth, is pointed out, with great precision, when a cause, before wanting, began to exist, of which the production of those strata was the first operation. That cause is specified in the following passage: "The beginning," he says, "of all the operations of which we observe the effects upon the great bodies of the universe, and in particular upon our globe, is an epoch in time, determined by the new accession of *light*, which, united to their other elements, gave room for the exercise of chymical affinities, and for all the physico-mechanical operations thence resulting[1]." From this union, consequently, the beginning of all geological phenomena takes its date. On this point M. de Dolomieu, in his Mémoire sur les Pierres composées, &c. asserts his general agreement with De Luc that "there was an epoch at which an essential change must have taken place on our globe, since from thence resulted all observable phenomena, which had not been previously produced."

Light[2], then, in the theory of the author, is the

[1] Abrégé de Principes et de Faits, &c. p. 93. Letter II. §. 42. See likewise the author's 20th Letter to M. de la Métherie, "Sur un commencement assignable des phénomènes physiques observés à la surface de notre globe, et sur la cause de l'état actuel de nos couches." Journ. de Physique, tom. xl. pp. 180—197. (1792.) "An epoch," he remarks, "is here determined, agreeably to the only general rule applicable to such an enquiry; that of judging of past causes by their existing effects, as far as these last can lead us. ....The proposition will be established, if its legitimate consequences explain the present state of the globe."

[2] Letter II. § 38. § 41. III. § 2. et seq. Journ. de Physique, Tom. xxxvii. part ii. p. 332. xl. pp. 184, 185. 288, 289. xliii. p. 20.

"It is certain that, when none of those operations of physical

the active principle which has occasioned such a change, and the introduction of which was requi-

causes, of which we observe the monuments upon our globe, had yet commenced, *light*, as a chymical ingredient, was wanting to its mass. For if light had always existed there, it would have produced fire, and fire liquidity; thence would have resulted all the various precipitations, the catastrophes of strata, the birth of our continents, and the action of atmospherical causes upon them: and these last effects would every where have been terminated, so that we should have been almost unable to trace back any of the links of their series." Elem. Treat. § 66. (a.)

" A fluid state of the globe," says Dr. E. NARES, " at least superficially, seems not only to be consistent with the Scriptures, and to be demonstrable from the figure of the earth, but to be a point in which philosophers, ancient and modern, have been always more agreed than in any thing else; the Huttonians being almost singular, if not entirely so, in their denial of it."

The celebrated passage in the First Book of Cicero, De naturâ Deorum, may here be introduced :—" THALES, qui primus de talibus rebus quæsivit, aquam dixit esse initium rerum—Deum autem *eam mentem, quæ ex aquâ cuncta fingeret.*" In the last clause of this passage, an immediate reference has been supposed to be made by the Milesian philosopher, to the phrase " Spirit of God which moved on the surface of the water," and by whose pervading energy the water produced all living things. See likewise the Theogonia of Hesiod, and Ovid. Metam. Lib. I. Thales had borrowed that dogma from the Egyptians and Phenicians, who, as well as the Chaldees, had preserved several remains of the Mosaic cosmogony; and Homer had in like manner maintained that the " ocean" was the first material principle of all beings. " The opinion of Thales," says Bishop Stillingfleet, " seems to have been part of the universal tradition which was continued in the world concerning the first principles of things;" and he quotes the authority of Aristotle in corroboration of his sentiment. Metaphys. Lib. I. cap. 3. The ὑδὼρ of Thales, according to that Prelate, and other learned men, was the same with the Egyptian Μωτ (*i. e.* the primordial mud or slime); the ὕλη of Plato and Pythagoras; and the ἰλὺς of the old Orphic cosmogony, mentioned by Apollonius in the Fourth Book

site by its union with a particular element, for the

of his Argonautics, as cited by Grotius, de verit. Relig. Christian. Lib. I. § 16. ἐξ ἰλύος ἐβλάστησε Χθὼν αὐτὴ, "the earth is produced from mud." See Origin. Sacr. Lib. III. cap. ii. STANLEY'S History of Philosophy, Part I. cap. vi. and Dr. PRICHARD'S excellent Analysis of the Egyptian Mythology.

Dr. Nares concurs with De Luc, in considering the first introduction of light into the chaotic mass, as the "first step towards its change," and observes that WALLERIUS, the celebrated Swedish mineralogist, had also expressly ascribed to the introduction of light "the first fluidity of the chaos, and the commencement of the attractive influences." "De Luc and Wallerius," he further observes, "though they make light the first physical cause of fluidity or liquidity, very properly refer its production to the immediate act of God." Bampton Lectures, pp. 320, 321. These are the words of Wallerius:—"Per spiritum Dei intelligendum arbitramur ipsum Deum, vel immediatam Dei actionem et operationem, seu, ut Eusebius in Præp. Ev. L. VII. Cap. XI. loquitur; vim omnium rerum effectricem atque fabricatricem, p. 109. Hac vi divina, existimamus, non extrinsecum quendam motum in immensæ molis massâ terrestri, quasi à vento, ut nonnulli dicunt, fuisse productum, sed intrinsecum, lenem, et pacatum, combinationi et cohæsioni particularum magis idoneum, quo terreum principium cum lucis materia fuit plus minus combinatum. A combinatione materiæ lucis cum principio terreo, materia calorifica primam suam habuit originem; hæc generata materia caloris, cum reliquis particulis terrestribus intimè mixta, non potuit non totam massam in motum intrinsecum, seu fluiditatis statum redigere." Meditationes Physico-Chemicæ de origine Mundi, à Joh. G. Wallerio, Stockholmiæ, 1779.

The following passage, which occurs in a commentary by our author on the three first verses of the Book of Genesis, is extracted from the "Précis de la Philosophie de Bacon," Vol. II. p. 129: "The expression, 'and the earth was without *form* and void,' contained in that sublime preamble, is profoundly geological. The earth was without 'form;' because it was as yet only a mass of elements united by a first creation, but which could not of themselves assume either the spherical form by gravity, or the spheroidal by the movement of rotation, or any form in its parts by affinities, because *liquidity* did not yet exist. . . . . . .

production of *fire* [1], and by its means, of *liqui-*

" 'And darkness was upon the face of the deep.' Here again we have a lively image, as well as a true declaration of what geology teaches us respecting what must have been the state of things immediately antecedent to all the physical operations on our globe, by the agents which God had established in the universe. The *element* of water······surrounded indeed, to a great depth, the whole unshapen mass of the earth, [Letter III. § 6. of this collection] mingled with other elements, and in particular with that which, together with *light*, produces *fire*; but although every thing was thus prepared for subsequent operations, these did not as yet commence, because *light* did not exist in the universe: accordingly, 'darkness'—the absence of light—prevailed over the aqueous face of the earth, previously to that great command of the supreme will: 'let there be light!' "

תהום, in our version, translated the "deep," and מים rendered "waters" are supposed by Bp. HORSLEY, (Biblical Criticism, Vol. i. p. 64), and other Oriental scholars, to denote the whole chaotic mass, containing the principles and elements of all things.

" The fire or caloric which has penetrated the earth, and the other planets to the centre, could not have existed without *light*; for the latter is one of the essential elements of caloric; but whence proceeded that primitive light? Moses informs us in the Book of Genesis; 'and God said, let there be light, and there was light.' This light is anterior to that of the sun; and, indeed, the sun does not appear, as a luminous body, before the fourth day of the creation; it was then only that it began to enlighten the earth. In respect to the creation of the sun, it was already announced in the first verse of Genesis:—'In the beginning God created the heavens and the earth.' The sun was, therefore, created at the same time with the earth; but it is to be supposed that at first they were both of them opaque, neither emitting, nor reflecting any light." Mémoire sur la Chaleur intérieure de la Terre, par M. J. A. de Luc, neveu. Bibl. Univ. Tom. xviii. p. 58. 1821. " Hebræi dicunt solem primo die creatum," remarks the learned Scripture annotator, VATABLUS. Thus, according to MAIMONIDES, the "luminaries" were created on the first day, but did not exercise their influence until the fourth.

" [1] All the experiments and observations relative to *fire*, have led us to conclude, that this fluid, subtle as it is, is not a simple sub-

dity[1]; without which the formation of the mineral strata could not have taken place.

stance; that it is composed of light, and of another substance belonging to the atmosphere, and to terrestrial bodies; and that the solar rays, in uniting themselves with this latter substance, produce heat upon our globe, but only by the formation of fire. This substance, therefore, might be intermixed with all the other elements which formed the primitive mass of the earth, without producing heat, or, consequently, liquidity; for it was not fire itself, it was only one of its ingredients, which, without the addition of light, could not constitute fire." Element. Treat. p. 57. See also Letter II. § 34. et seq. III. § 31. Journ. de Physique, Tom. xxxvii. (Part ii.) pp. 54—71. [Lettre VIème à M. de la Mêtherie, sur les rapports qui régnent entre la Lumière et le Feu.] Tom. xl. p. 180. et seq. pp. 288, 452. xlii. p. 237.

[1] "It is now established as a fact in chymistry, and in natural philosophy, that the *liquidity* of every substance is exclusively produced by a certain union of the calorific fluid with its molecules; an union by which this fluid, known to former natural philosophers under the name of *fire*, and among some of the moderns by that of *caloric*, loses its faculty of producing heat, while the other substance loses the distinctive properties of solids, and assumes those of liquids." Element. Treat. § 62. Letter II. § 34. Journ. de Physique, Tom. xl. pp. 184, 185.

Accordingly, when liquidity did not as yet exist on the globe, a sufficient quantity of fire was wanting for the liquefaction of water. But by the addition of light, the earth was every where penetrated with fire, and a liquidity of high temperature was produced in the elements of which it was composed. Letter II. §§ 34, 35. Journ. de Physique, Tom. xl. p. 188.

"The volume of the earth's mass being about 10,000 times greater than that of the mass of waters, it is very probable that the fluidity which the globe incontestably possessed, before assuming its spheroidal form, was owing to *heat*." Jameson's Ed. New Phil. Journ. 1827-8, Vol. iv.

Origin assigned to the Mineral Strata and to the Atmosphere.

On the origin to be assigned to the mineral strata and to the atmosphere, De Luc has adopted, in common with those eminent geologists, De Saussure and Dolomieu, the following theory:—"Chymical precipitations, successively different, took place in a liquid originally covering the whole globe, in which the elements of the mineral strata and of the fluids that compose the atmosphere were held in a state of reciprocal dissolution, and of which the liquid of the present sea is the residuum[1]." The above system,

[1] Letter II. § 18. III. §§ 18, 19. "The study of the primary mineral substances," says Mr. J. A. de Luc, "leads us necessarily to the idea that they were formed by crystallization in an aqueous liquid which covered the whole terrestrial globe to a great depth at all latitudes, beneath the poles as well as under the equator, and that this liquid was every where at the same high temperature. An immense quantity of caloric was requisite to hold in a state of liquidity all the mineral substances, both earthy and metallic with which we are acquainted, down to the granite, and to produce the primitive liquid of which the waters of the ocean are the residue; the degree of heat which must have prevailed at that time, was much greater than any which we ever experience at the earth's surface by the mere influence of the solar rays, and that heat must have penetrated to the centre of the globe. This temperature, which was uniform at all latitudes, must have existed a long time after the formation of the primitive rocks; it still prevailed to a certain degree subsequently to the appearance of terrestrial organized bodies, as is rendered evident by the impressions of plants, and the bones of the large quadrupeds found at very high latitudes, (72 and 75 degrees) and whose genera exist at present only between the tropics." Mémoire sur la chaleur intérieure de la Terre, par J. A. de Luc, neveu. Bibl. Univ. Vol. xviii. p. 58. 1821.

he says, is in perfect accordance with the general laws of chymistry [1]; and with the addition of another cause, namely, the introduction of new substances into the liquid, occasioning these precipitations, it affords a complete explanation of all the phenomena of our mineral strata and of the atmosphere. Such

The central heat of the earth was likewise demonstrated by our author:—"The rocks," he observes, "and the bottom of the high valleys of the Alps, although covered with ice, always participate more or less in the interior temperature of our globe, and for that reason the ice melts at all seasons underneath, however intense may be the cold at the exterior. In the depth of winter······the rivers continue to issue from the interior parts of the ice." Lettres sur l'Histoire de la Terre, &c., Tom. i. p. 140. 1778. De Saussure, desirous to verify this observation by personal inspection, (Voyages dans les Alpes, §§ *533*, *534*) visited the glaciers of Chamouni in winter, and perceived that, according to De Luc's statement, currents of water flowed from all the glaciers of the valley, less copiously indeed than in summer, but always in considerable streams. See further, Letter III. §§ 31—34. Journ. de Physique, Tom. xl. pp. 452, 453. xlii. p. 237. See also our author's Recherches sur les modifications de l'Atmosphère, Tom. ii. pp. 327, 328. 1772; a work remarkable at once for a scrupulous analysis of the phenomena of which it treats, and for the circumspection with which the investigation of their respective causes is carried on. "In that work," remarks Prof. Playfair, "De Luc has succeeded where many men of genius have failed, and has made considerable improvements in a branch of the mathematics, without borrowing almost any assistance from the principles of that science." Illustrations of the Huttonian Theory.

[1] Letter III. §§ 14—19. IV. § 7. "If the details of specific affinities, as yet furnished by chymistry, can afford us no assistance, while we attempt to particularize the first operations which took place on our globe, this is by no means the case with the general laws which have been determined in that science; for they lead us to generic operations, whence much light is thrown upon these beginnings." Element. Treatise, &c. § 60. See also Journ. de Physique, xl. p. 286.

is the only road by which we can ascend to the succession of physical events that were brought to pass on the globe by causes now no longer existing[1]. The first discernible effects, then, of these causes, were precipitations continued for a long time, of substances differing successively in their genera and species, and spread out in strata,—the greater part of them solid, and the rest soft,—over large tracts of the bottom of the liquid, and in a situation nearly horizontal[2].

These strata, in the intervals of their formation, and until the end of these operations, were subjected to a series of catastrophes, in the course of which they were divided by fractures and dislocations into masses which became ridges of mountains, having undergone such angular movements that valleys were

[1] Travels in France, &c., Vol. ii. p. 381. Journ. de Physique, tom. xl. pp. 180—197.

[2] That the most ancient strata of our globe, now found strongly inclined, and sometimes even vertical, were yet formed in a horizontal position, was first ascertained by De Saussure, from his observations on the breccias or pudding-stones of the Valorsine. See the second volume of "Voyages dans les Alpes," §§ 689, 690. Strata, which originally were so soft as to enclose fragments of other stones, could have been formed of an equal thickness only in a horizontal position; their substance would have slidden to the bottom in one mass. Element. Treatise, § 142. 1809. The interposition of pudding-stone, says our author, between the classes of homogeneous strata begins even among the primordial: for M. de Saussure has shown instances of it, as well between granites and schists, as between these two first classes and the calcareous strata, and between the latter and the strata of sand-stone; besides many repetitions between different species of the same genera. Geol. Travels, Vol. i. § 76. 1810. Element. Treatise, § 320. The original horizontality and continuity of the strata of later formation, are evidently shown by the marine and other organic bodies contained in them.

necessarily produced in their intervals [1]. Our mountains then, in the opinion of the author, exist under

[1] This, however, is not the only cause which has operated in the formation of valleys. There has been another cause, (as manifested by the phenomena,) which has been already adverted to, and upon which much light has of late been thrown by Von Buch, Mr. J. A. de Luc, jun., and other geologists. See note to Letter I. § 21. By some violent agency, the mountains have been, in many instances, cut asunder, whereby a passage has been opened for the waters, without the least angular motion of the strata. The transversal valleys in the great chains of mountains, observes Mr. J. A. de Luc, are not to be explained by the subsidence or elevation of the strata. "In respect to the valleys of denudation," (he further remarks) "as they are termed by the English geologists, they have been excavated beneath the ancient sea which possessed a dissolving, or corroding power, and they must have required a long abode of its waters for their production. This was also the opinion of De Luc, when he ascribed so many phenomena to the operations of the ocean."

The following general views respecting the formation of valleys have been recently communicated by Mr. J. A. de Luc, to the editor:—

"When we take the word *valley* in its most general acceptation, as comprising not only the valleys which traverse the great chains of mountains, but also those which cross the hills and plains, we may distinguish eight modes of formation.

1. By subsidence, in such a manner as to occasion strata which have been formed horizontally to break and sink down on one side, and on the other to rise up and present their summits upwards. If two subsidences take place in opposite directions which meet towards the lowest extremity, the result is a basin or a valley.

2. By elevation, whereby the strata have been turned up, and great masses have been forced to assume a vertical position. In that case we can readily imagine that valleys must be formed on the two sides of those strata thus raised up.

3. By lateral pressures which have bent the strata, and have caused them to present their convexity either upwards or downwards.—These modes of formation are connected with the origin of chains of mountains, as yet unexplained.

their present form, only because portions of the strata, once a continuation of those which compose these

4. By violent fractures which have occasioned transversal breaches of more or less breadth, in ranges of continuous mountains, unattended by subsidence or elevation. Here we may place the valleys of *disruption*, spoken of by Professor Sedgwick, in the direction of the crevices and fissures produced by great elevating forces.

5. By the erosive and dissolving power of a liquid which has excavated the surface of a great extent of strata, and has thus hollowed out valleys, sometimes simple, sometimes ramified, called *valleys of denudation*. The same force has produced the diluvian gravel.

6. But what is the cause which has excavated the great chains of mountains, so as to form vast irregular basins, each comprising a great number of valleys of three different orders, which all open into each other, terminating in a general outlet which is that of the principal valley. Thus the basin of the valley of Aoste, which terminates at Ivrée, comprises twenty-five valleys of the second and third order; the valley of the Durance, which terminates higher than Avignon, comprises thirty-three. How have those systems of valleys been formed, which divide the whole chain of the Alps into irregular basins? This is the great problem which remains to be solved.

7. Another cause, which is only secondary, is that which has widened subsequently or simultaneously the gorges formed by transversal disruptions of the ranges of continuous mountains. We may conceive that at the moment of those disruptions which were produced in the bosom of the ocean, the violent motions in its waters thence resulting, occasioned them to bear away with them the debris, and to convey it to a distance. After the retreat of the sea, or of great bodies of water in general, the rain waters, the falling in, and crumbling down of large masses of all dimensions, the streams which form in those valleys, have all contributed to widen them, and have at one time excavated them more deeply, and at another time filled them up. [See Letter I. § 21. note.]

8. A great number of channels, more or less deep, have been excavated by rivers in the soil formed by transported matter, such as we observe them in the basin of Geneva, in which the Arve and the

eminences, have sunk around them. From such subsidences have resulted valleys and plains, and the cavities of lakes [1]; and the eminences already formed by anterior catastrophes, were left on our continents as mountains, by the removal of the ocean to its new bed.

Changes in the Nature of our Mineral Strata. Catastrophes which they have undergone. Causes of those two great Geological Phenomena indicated.

The successive changes in the nature of our mineral beds, and the disturbances which they have suffered, form two of the most important phenomena of geology. If the formation of the different kinds of strata is of necessity to be ascribed to precipitations successively differing in their nature, the changes in the pre-

Rhone have hollowed out channels in the diluvian accumulations of pebbles, gravels, sands, clays, &c. to the depth of 100, 200, and 300 feet; but those channels are not, strictly speaking, valleys."

[1] "That many of our mountains," says Mr. J. A. de Luc, "have been formed by the overthrow and subsidence of the strata, we cannot entertain a doubt. Of this fact we have several instances in the calcareous mountains which constitute the exterior range of the Alps near Geneva, and on the southern side of our lake. Our basin itself can have been formed only by a depression which has separated the chain of the Alps from that of Jura. The theory, however, of subsidence is applicable to some parts only of the Alps, and of the other great chains, particularly to the calcareous ranges." "Because some mountains," the same geologist remarks, "have been raised by subterraneous action, it has been inferred that the whole of our continents has also been raised. No conclusion can be more erroneous." Letter to the Editor.

cipitations must as necessarily have been produced by corresponding changes in the liquid[1]. But, it would be only by the introduction of new ingredients that the changes in the liquid could be effected; and the mode in which these new ingredients were introduced, was by ascending through the crevices of the fractured strata from the interior parts of the globe[2]. These first and legitimate conclusions, deduced from existing monuments, serve, says the author, to explain a variety of phenomena that would otherwise be involved in obscurity.

The general cause of those catastrophes which determined the present form of the earth's surface, is particularly considered in the following Letters, and may be thus summarily stated:—The globe was originally composed of disunited particles, or pulvicules[3],

[1] Letter III. §§ 18, 19, 22. IV. §§ 17, 18. Journ. de Physique, Tom. xxxvii. (part ii.) p. 213. et seq. and p. 332. xl. p. 285. et seq.

[2] Letter IV. §§ 16, 17. The following application of this theory to an interesting geological phenomenon occurs in the first volume of the Geol. Travels, § 135.—Adverting to the fragments of flint disseminated in the sand, near Berlin, as also in Westphalia, and the country of Bremen, "these flints," the author observes, "are of the kind belonging to chalk, though there is not the smallest appearance of chalk in the whole neighbourhood. In my Lettres sur l'Histoire de la Terre, &c., I have, as I believe, assigned it to its true cause: namely, that, after the primordial liquid had produced the strata of chalk, in which these flints were formed, new precipitations, occasioned by new ingredients proceeding from the interior parts of the globe, altered so much the state of that liquid, in certain places, that substances, before separated from it by precipitation, were again dissolved by it; a circumstance of which I have given other examples. Now when the chalk was dissolved, the flints, not being soluble, alone remained."

[3] This word was first adopted by the author, who had found none

on which, after liquidity had been produced, were deposited in the first place, strata of granite, and others analogous to granite [1]. These strata, resting on so slight a foundation, underwent repeated fractures; and the introduction of the liquid through these apertures into the interior parts of the earth, occasioned the subsidence [2] of the elementary particles, and produced *cavities*, which by degrees increased in extent, and became deeper, till at last they caused the catastrophes of the different classes of strata [3],

that exactly expressed his idea. Letter III. §§ 3, 24. In the Journal de Physique, 20th Letter to M. de la Métherie, Tom. xl. p. 185. et seq. (1792) this part of the theory is fully developed. See likewise Abrégé de Géologie, § 17. et seq.

[1] "The first of the strata we are acquainted with, namely, those of granite, and others of the same kind, were deposited on a great accumulation of mud intermingled with a liquid. This liquid gradually filtrated into the mass of pulvicules, and there produced subsidences, as we see to be the case with heaps of sand or other powders when we pour water on them." Letter III. § 24. For an account of granite, stratified and unstratified, see Letter IV. § 6. (note.)

[2] Letter III. § 38. Journ. de Physique, xl. pp. 188, 189. 450—467.

[3] Long before M. de Saussure had shown that the catastrophes which had been discerned only in the secondary formations, had extended to the primordial also, De Luc, from a careful examination of the mountains composed of the former, together with their valleys, had been convinced that the only manner in which the catastrophes of the secondary strata could have been effected, was by the subsidence of the parts at present the lowest. See Travels in France, &c. Vol. i. § 21. Now such subsidence, he observes, could not have taken place any otherwise than by means of caverns previously existing beneath the strata. The subsidences of the strata, he elsewhere remarks in the same work, during which mountains and hills were formed by the masses remaining at a higher

formed in succession by chymical precipitations from the liquid which once covered the whole surface of the globe. These precipitations were occasioned by expansible fluids[1] formed by the combination of the

level, were attended with other subsidences within these masses themselves, intersected throughout with fractures; between which, in some places where the upper parts found support on the sides, those between them sank down to a greater depth, leaving in the intervals the spaces which are called caverns. See also Travels in England, Vol. iii. § 1035, where he refers to his description of the caverns of the Mendip hills for proofs that it is by subsidence only that such cavities could have been produced in the masses of the strata; and to the caverns at Buckfastleigh for an "example of deep fractures, which, when they have not passed across all the strata, have occasioned the unequal subsidences of the different parts of the masses thus separated." See likewise Travels in France, &c. Vol. ii. § 655. et seq., where the author speaks of the caverns in Bayreuth. "It may easily be judged," he says, "that these caverns have originated in the cause to which I have ascribed all cavities of this kind; namely, a more considerable subsidence of the inferior strata than of the superior; for, in the interval thus produced between them, some large masses detached from the latter are found in a nearly vertical position." § 660. *Elevations* of the strata, of which the cause must have acted from below, could not have left any intervals between them, the pressure of the inferior beds beneath the upper ones having alone the power of raising the whole mass.

[1] Letter III. §§ 16, 19, 24, 48. IV. 16, 17. V. 6. Journ. de Physique, tom. xxxvii., part ii. p. 34. xxxviii. pp. 274, 275. xl. p. 189, et seq. "Expansible fluids constitute the class of substances which it is the most important to study in all its modifications; for those fluids, in our own experiments, are the vehicles of ingredients, impalpable in themselves, but which, when separated from, or introduced in liquids occasion in them new combinations. From this class of phenomena, therefore, I have deduced, by general analogy, the chief cause of the successive different combinations which produced the primordial liquid."

liquid with the particles into which it had penetrated. In proportion as the liquid was divested by precipitation of its primitive ingredients, changes were effected in the liquid itself, and the successive infiltrations were of different natures. New species of expansible fluids were accordingly produced, and precipitations of various kinds were the necessary result. The concretion of large masses, variously ramified, was another effect gradually caused by the infiltration of the liquid into the interior pulvicules. Those consolidated masses formed the partitions of the caverns, and served as supports of the crust of the strata, till the supports themselves gave way, in consequence of the subsidence of the pulvicules beneath them; and the crust broke and sank down, to a greater or less extent, in the intervals of the supports [1]. It was not until after the sinking of those partition walls, that stability was produced [2].

See likewise the 29th, 30th, and 31st Lettres à M. de la Métherie, tom. xlii. and xliii. of the Journ. de Physique. In these last Letters will be found a masterly analysis of the physico-mechanical theory of the celebrated LE SAGE, the friend and fellow-countryman of our author. In common with LA PLACE, BAILLY, LICHTENBERG, HERSCHELL, and other eminent men, whom he names, and with all of whom he had occasionally conversed on Le Sage's system, he arrived at the following conclusion,—that if there exists a *mechanical cause of gravity*, it is probably the cause determined by that distinguished philosopher, since it cannot be contradicted by any known phenomena, and is adequate to explain them all.

[1] Letter III. §§ 24, 38. Journ. de Physique, tom. xxxvii. (part ii.) p. 342. xl. pp. 186, 187, 188. Abrégé de Géologie, p. 17.

[2] In Letter III. §§ 41, 42. and in Geol. Travels, iii. p. 375. et seq. the whole of these operations will be found very ingeniously and accurately illustrated by similar natural processes on a smaller scale.

Such, according to our author, was the cause of the various disturbances which the mineral strata underwent; and which supplies us with a general explanation of the two following great revolutions:— "The first of these was the division of the surface of the globe, while it was yet covered with the primordial liquid, into sea and land, in consequence of the depression of a portion of that surface, on which the whole of the liquid was collected—thus giving existence to first continents[1]; the second was the sinking of those ancient continents, which were consequently again covered by the ocean. Its waters had found their way into the caverns which the first tracts of land covered, and had penetrated into the porous and disunited substances which had not as yet subsided. Those caverns were thus gradually deepened, the foundations of the supports of that portion of the crust were undermined, and the first continents sunk below the level of the first sea. By this last revolution, our present tracts of land were produced[2]." In

[1] Letter III. §§ 26, 27. Those continents, in the opinion of the author, were inhabited by the antediluvians. It would seem, however, that in our regions of the globe, there existed likewise at some remote period, a vast continent, a great portion of which afterwards became the bed of the sea. The proofs of the existence of such a continent are grounded on the universality of the phenomenon of the fossil remains of vegetables and terrestrial animals. See the sequel of this section.

[2] Letter IV. § 41. Correspondance entre M. le Docteur Teller et De Luc. Hanovre, 1803. p. 134. Lettre 26ème. à M. de la Métherie, tom. xli. (part ii.) pp. 227, 228. 1792. Prof. Hollmann, of Göttingen, in a dissertation presented to the Royal Society of that university, maintained in like manner that our continents were once the bed of the sea, and that they were left dry by the sinking

the course of that great revolution, the sea covered all the globe, except the islands of its ancient bottom,

of ancient tracts of land. He communicated his dissertation to De Luc in the year 1776, who in his Lettres sur l'Histoire de la Terre, &c. Vol. v. part ii. p. 487, noticing this coincidence of opinion, remarks that the Professor and himself arrived at this conclusion by very different roads, and that it must be indicated by many phenomena, since the former deduces it from those which he had the opportunity of observing in his own country. The dissertation is translated into French, and inserted in the Journal de Physique de l'Abbé Rozier, and M. de la Métherie. In the third vol. of the Geol. Travels. § 1179, a striking instance is adduced corroborative of the opinion " that the bed of the sea is the effect of a vast subsidence, in which the strata were broken off on the edge of what, by the retreat of the sea towards the sunken part, became a continent." See also Geol. Travels, Vol. iii. p. 541, (" Varieties, fractures, and inclinations of the strata, with evident signs that the present bed of the sea has been produced by their subsidence, described,") for several references to similar instances. It may be asked, in what part of the globe was the destroyed continent situated? It has been supposed that there formerly existed between Africa, a portion of Europe, and America, a large continent of which the Madeiras, the Canaries, the Azores, and the islands of Cape Verd may be considered as the wrecks. The sunken continent has been identified with the Atlantis of Plato, and BAUDELOT (Histoire de l'Académie des Inscriptions, 1721) has no doubt that the overwhelmed island, which is described as situated opposite the strait called the columns of Hercules, and as larger than Lybia and Asia, existed in the Atlantic ocean. KIRCHER in his Mundus Subterraneus, and BECKMAN in his History of Iceland, assign the same place to the subsided land; and Buffon inclines to a similar opinion. It has been thought that the shallowness of the Atlantic sea, as far as the Canaries, constituted a proof of the submersion of the Atlantis by the ocean. The Madeiras, however, the Canaries, and the Azores, cannot be the fragments of a great continent. They are volcanic islands, the products of eruptions, and which have been elevated from the bottom of the sea. " Forms and Relations of Volcanos, from the Observations of Leo-

which increased in number and magnitude, but continued still separate, until the weight of the water, added to that of the superior vaults, crushed the inferior ones, and deepened more and more the new bed of the ocean; so that, at last, all the waters withdrew from their former bottom, and left our continents dry [1].

Proofs of a Series of Geological Events, originating in Changes at successive epochs in the Liquid of the Sea, and in the Atmosphere.

The first proof supplied by the phenomena of such a succession of events, consists in the changes which the various circumstances observed in our strata demonstrate to have taken place at several epochs, both in the liquid of the sea, and in the atmosphere. Within a certain period was formed a class of strata,

pold Von Buch, by Mr. ELIE BEAUMONT." Edinb. Journal. Sept. 1830.

Mr. J. A. de Luc has conjectured, on the other hand, that the antediluvian continent was situated where is now the great Indian ocean, and to the eastward of Africa, as that sea is near Armenia and Mesopotamia, the countries in which dwelt the descendants of Noah. He considers the dialogue of Plato to refer to the Mosaic narrative of the deluge. In the Atlantis, there existed kings who, stimulated by the thirst of conquest, committed devastations upon neighbouring states. Jupiter, whose all-pervading eye nothing escapes, beholding the violence and depravation of those people, resolved on their destruction.

[1] Letter II. § 29. Lettres sur l'Histoire de la Terre, &c. Vol. v. part 2d. p. 486. et seq. See also the Author's 26th Letter to M. de la Métherie, in the Journ. de Physique, tom. xli. (part ii.) pp. 227, 228. 1792.

distinguished by the title of primary or primordial, in which no traces of the existence of organized beings on our globe are discoverable. In another class of strata, called secondary, which were subsequently produced, and which differed widely in their nature from the preceding, vast quantities of organic bodies are found [1]. The greater part of these bodies consist of marine animals; and in strata above those containing the marine bodies, we meet with vegetables and terrestrial animals. It is to be remarked, that in the succession of these strata are found successive changes in the species of the organized bodies, following those which have taken place in the water and the atmosphere [2].

[1] Although the author, for the sake of perspicuity, generally divides the mineral strata into these two great and characteristic classes, yet it will appear, from a passage in Letter II. pp. 62, 63, that he already entertained notions, in agreement with those which prevail at this day, respecting the series of formations.

[2] Letter IV. § 18. "Geological monuments," says the author, "are much more within our reach, than those from which the history of ancient nations is deduced. These monuments relate to two collateral histories,—those of our strata and of organized beings. We find in each of these histories, epochs of commencement which are clearly ascertained; that of the strata, is the commencement of their formation,—and those of organized beings, which succeed each other in classes, are the commencements of the appearance of these classes in the succession of strata. We also observe in each history progressive changes: in respect to the strata, we perceive the successive production of strata of different species; and with regard to organized beings, successive changes in their appearance."—"Remarques sur l'origine des Etres Organisés," a dissertation annexed to the Paris edition of this collection. So early as in his Lettres sur l'Histoire de la Terre, &c. (1779), De Luc pointed out the difference between the genera of petrified and fossil shells,

The immediate relation which these facts bear to the whole progress of chymical operations above adverted to, is fully explained by the author in the present, and in other works. It was during the precipitations, that numerous expansible fluids, of various kinds, were disengaged from the liquid, and combined to form the atmosphere, "that confused assemblage of fluids," as De Luc terms it, "which astonishes none but naturalists[1]." Further;—if no vestiges of organized beings, vegetables, or animals, whether marine or terrestrial, are found in our primary strata, it is because neither the liquid nor the atmosphere was in a state proper for their existence; but afterwards, when they did exist, they underwent successive changes, in proportion as the liquid and the atmosphere themselves varied. Now that successive revo-

and the living kinds; he showed that there are genera having numerous species in their fossil, and few in their living state; and the reverse. Vol. ii. p. 246. In Vol. v. pp. 456—459; 466, and 507, he points out two differences, first, of marine fossil bodies, whose living analogues have not yet been found in any sea; secondly, of others whose analogues are to be met with only in seas extremely remote. It may here be remarked that with De Luc originated the idea that the different species of marine animals changed with the strata. See Letter III. § § 50, 51.

[1] Letter IV. § 17.—"General chymistry teaches that chymical precipitations, always produced by the addition or subtraction of some substance, or by both operations simultaneously, may be occasioned by expansible fluids, whether ponderable, or imponderable. Accordingly the chymical operations which have produced the mineral strata must have disseminated all around the globe a great accumulation of different species of expansible fluids, and have thus given birth to the atmosphere." Correspondance entre le Docteur Teller et De Luc, p. 357. In that work the author describes the atmosphere as being probably the greatest chymical laboratory of nature upon the globe.

lutions at the bottom of the sea were the cause of those two classes of changes, the following is the direct proof:—Since the cessation of the catastrophes, no precipitations have taken place in the ocean; nor have any perceptible changes in organized beings occurred. All precipitations, and all such changes, were terminated by the revolution which changed the bed of the sea, and thus brought the surface of the globe into its present state of stability[1]. Of this great revolution, there is the clearest evidence. Since there was a period during which the sea was at a much higher level than it is at present, more elevated lands must have then existed, which served as barriers to its waters[2]. Such continents must therefore of necessity have sunk, before the ocean could have retired from the surface of our present tracts of land. And that the emersion of our continents was the effect of a *single revolution,* would appear from the important fact, that since then the level of the sea has not changed. This is rendered manifest from the circumstance that all new lands, which every where may be easily distinguished from the original coast, are perfectly horizontal, excepting where they have suffered partial depressions behind dikes; and their level has been determined by the largest waves at the highest tides[3].

[1] Travels in France, vol. ii. p. 390. [2] Letter V. § 4.

[3] An interesting passage on this part of the subject, occurs in the Travels in the North of Europe, § 114. Having shown in a preceding section that the new lands along open coasts and in gulphs, are composed " not only of the sediments of rivers, but of the materials detached from some parts of the coasts, and of the sand of the sea," De Luc thus proceeds:—" Now, as these accu-

It is impossible not to be struck by the sagacity and the powers of observation which have enabled

mulations of materials have, and can only have been produced, in all their parts, at the greatest height of the tides and of the waves, they must, when considered altogether, afford us a *history of the level of the ocean*, during the whole period in which it has occupied its present bed. This standard of the level of the sea is one of our most important geological monuments; for by it alone, several fabulous histories of the earth have been overturned. For example: in Buffon's theory, the sea was represented as passing slowly from east to west, and constantly attacking and demolishing the eastern coasts, while it retreated from the western; which supposed a slow transportation of the continents around the globe. Among other arguments, which, in my first geological work, I opposed to this idea, were the following: first, that new lands have been formed on the coasts in every position, and particularly no less on eastern than on western coasts, wherever rivers discharge themselves, and the sea near the land has no great depth: and secondly, that, on every coast, these additions are as *horizontal* in their whole extent, as the sea, of which they occupy the place. BUFFON lived for some time after I had published that work; and neither himself, nor any other for him, ever undertook to support his system against it. DE MAILLET and LE CAT supposed our continents to owe their existence to the successive sinking of the level of the sea; the former imagining that the water evaporated, and was lost in space; and the latter, that the sea was continually deepening its bed, by throwing out on its shores those materials, with which our continents were formed. After having refuted the fundamental hypotheses of these theories, I stated, as a common objection to both, that all the lands formed by the sea upon its shores are every where perfectly distinct in their composition from those to which they are joined; that they are absolutely horizontal, from the point of that junction, to their actual extremity; and that they are continuing to increase: which circumstances irrefragably prove, 1st. that the existence of our continents is due to some cause entirely different from those which are still in action, and particularly from every operation of the present sea. 2dly. That the original coasts of our continents were com-

De Luc thus to connect the successive changes in the precipitations that took place in the ancient sea, and the corresponding changes in the nature of the atmosphere, first, with the changes in the organized beings, (changes easily ascertained by comparing the fossil with the living species) and afterwards with their common and immediate cause, viz. successive subsidences of different parts of the bed of the ocean [1].

posed of materials similar to those of the highest neighbouring grounds; to which, in many places, the sea has added new lands, shown by their characters to result from its operations on its shores; no such characters being found in any other part of the continents. 3dly. That since the sea began these operations, its level has never changed. And 4thly. That from the known progress of these lands, the sea cannot have occupied its present bed during a very great number of centuries. These are points which I do not know that any formal attempt has ever been made to overthrow."—"How can Mr. Lyell link the name of Buffon with that of De Luc, when the latter decidedly opposed the theory of the former?" Letter from Mr. J. A. de Luc to the Editor.

[1] "Meteorology throws light on geology, by manifesting the existence of a multitude of subtile fluids in the atmosphere, as well as their perpetual changes by chymical operations which take place in the soil; and geology in its turn throws light on meteorology, by pointing out, in the cessation of certain causes which have formerly acted on our globe, but the action of which has ceased, the reason of the present settled state of the atmosphere within a certain circle of changes." Correspondance entre le Dr. Teller et De Luc, p. 358.

Three general propositions have been established by the author in meteorology, the consequences of which he considers as very important in respect to the study of atmospherical and geological phenomena. 1. The ponderable mass of the atmosphere, for by far the greater part, is water. 2. Atmospheric air is water, combined with fire or caloric, and some other substances as imponderable as fire itself. 3. The greater number of meteors, and in particular rain, as well as the relation of the atmosphere with the soil

The cessation of the precipitations, is also necessarily connected by a common cause with the permanence of the sea at a fixed level, since its residence in a new bed:—there have been no cavities opened as before, into which its waters have penetrated; and out of which the expansible fluids rushing forth, could occasion fresh precipitations, or chymically affect the atmosphere. At the period of the revolution in consequence of which the sea changed its bed, a final and sensible change in the nature as well of the liquid of the sea, as of the atmosphere was effected; as is evidenced more particularly by differences observed between the fossil shells found in the loose superficial strata near the coasts, and the shells now containing living animals in the neighbouring sea [1].

The pre-existing fertile and populous continents were, according to De Luc, the source which supplied

and its productions, are the effects of actions exercised upon vapours, upon air, and upon each other, by different expansible fluids, having great chymical affinities, although as imponderable as fire, and the electric fluid.—Correspondance, &c. p. 353.

[1] Such likewise are the reasons of the great differences which Cuvier has discovered, in comparing the fossil bones found in the strata with those of the quadrupeds that now exist; differences of which an account may also be seen in Mr. Parkinson's valuable work, entitled Organic Remains of a Former World. In that work, Mr. Parkinson describes great numbers of marine bodies, which have been found in different strata, and many terrestrial vegetables, which are contained in those covering beds of coal, and have no analogues among the existing species; while, at the same time, the strata beneath the coal beds contain the remains of marine animals. The latter, as well as the terrestrial animals, continued to suffer changes till the epoch of that revolution on the globe which gave birth to our continents. See Travels in France, &c. Vol. ii. pp. 198, 199.

with plants and animals the islands[1] of the ancient sea. These islands were formed by the disruption of long

[1] Letter III. § 28. Journ. de Physique, xli. (part ii.) p. 221. et seq. 1792. That the surface of the ancient sea was divided by islands and projecting ridges of the strata is admitted by Cuvier. Essay, &c. p. 11. Notwithstanding, however, that the existence of islands in the ancient sea has been demonstrated by the author, (Letter V.) still these alone would scarcely account for the universality of the phenomenon of the remains of fossil vegetables and terrestrial animals. It would appear from the recent and constantly continued discoveries of such remains, that the soil now inhabited by man, which constituted to a great extent the bed of the sea immediately before its last retreat, formed, at some remote period, a vast continent occupied by plants and large quadrupeds. These fossil remains are dispersed over the whole surface of Europe, and are equally found in the north and the south of Asia. It is indeed possible, according to Mr. J. A. de Luc, the younger, from the circumstance of the bones of elephants having also been found in various parts of North America, and even within the polar circle in the Straits of Behring, that this great continent was formerly united on the one side to Europe, and on the other to Asia, at the place where it is now separated from the latter continent by those straits. In consequence of the last revolution which the earth's surface has undergone, that ancient continent, once inhabited by terrestrial animals, and afterwards overflowed by the waters, having been left dry, forms the greatest portion of our present lands.

Thus a preceding revolution, according to Cuvier, must have buried the osseous remains, and destroyed the last generation of the quadrupeds living at that epoch: and we are led to conclude that the bones found in the loose soils have belonged to many generations; the greater number of which had perished a long time before, and had left only their skeletons, or merely some of their bones the least destructible, such as the jaw-bones and the teeth, when the lands upon which these remains rested, passed under the waters of the ocean. Mr. J. A. de Luc conjectures, however, that the last elephants of Siberia, such as the individual brought to Petersburgh by Adams from the banks of the Lena, and which retained its flesh,

peninsulas, the result of anterior revolutions; during which, in consequence of large portions of the liquid

hair, and skin, occupied portions of land which had not been submerged, and perished in consequence of the sudden refrigeration of the atmosphere, their bodies being shortly after enveloped in the ice. Previously to that period, Siberia must have been a warm climate; and covered during the whole year with a vegetation sufficiently abundant to support a multitude of large quadrupeds. The sea must have been of an equally warm temperature, since it supported nautili in the 51st degree of north latitude, as in Flanders, and in England, that mollusca now living only in the Indian sea. Bibl. Univ. Vol. xix. p. 132.

Many facts relative to the situation of the fossil bones of elephants had been collected by De Luc in his Lettres sur l'Histoire de la Terre, &c. from which he had deduced the most just conclusions. Adverting to the bones of those animals found on the borders of the Meuse, the Rhine, the Lippe, and the Weser, he observes that those rivers attack their banks in certain places, sweep along with them the sand, and, at their retreat, leave on the shore the solid and heavy bodies which the sand enclosed. The bones are imbedded in a sand which had not been drifted by the Rhine, and that remained in the same state in which it had been deposited by the ocean. It is evident that the sea was formerly on the very spot where those remains are discovered, and at the time of their deposition; consequently the animals to which they belonged did not live in the places where they are found. De Luc means not to assert that the fossil bones came from the countries which lie between the tropics, but from isles or ancient lands, situated near the sea which had buried them in its deposits. During the revolutions to which such lands were subjected, the remains of those animals passed beneath the waters of the ocean, and were imbedded in the last strata which it deposited. In the deposits of bones at Caastadt, near Stuttgardt, we perceive, from the manner in which they were accumulated, that they had been transported from some other place by the waters of the ocean; the bones were lying without any order, much fractured, and sometimes rolled. In the same neighbourhood was discovered a forest of trunks of prostrated palm-trees, the soil near which these animals probably inhabited. They must have all perished on that

being absorbed through the interstices of the fractured strata into the interior parts of the globe, those eminences which had been produced at the bottom of the liquid were left uncovered [1]. Several of the islands underwent successive catastrophes, and sank beneath the level of the waters, with all their plants and animals, where they were covered with different species of mineral strata, which were subjected to repeated convulsions that continued to affect the whole mass from its base [2]. We are thus enabled to

soil, and left their bones of which the fleshy ligaments were decomposed; afterwards, owing to the subsidence of the soil, the waters of the sea came over them, and swept them into the cavities of the calcareous hills which at the present time border the valley of the Necker. In Russia, in the governments of Novogorod, Twer, Wologda, and Olonets, at ten or twelve feet under the surface, whole forests of trees, lying on the earth, and broken by some irresistible power, have been discovered. It was, perhaps, in these thick forests, that those enormous animals perished; they were buried at the same time with the woods in which they found their shelter and their pasture. Pallas informs us, that petrified woods are met with in the sand-hills of the plain to the east of Petersburgh; he adds, that in those sandy, and frequently muddy deposits, the remains of great quadrupeds are imbedded. Bibl. Univ. Vol. xix. p. 127. 1821.

[1] Journ. de Physique, Tom. xli. (part ii.) pp. 221, 222.

[2] Letter V. § 16. Having occasion to describe a bed of *surturbrandt* (fossil peat), covered by strata of white clay and heath sand, and supposed to extend over the whole summit of the Cattenbül, a mountain near Münden, De Luc remarks that such beds of fossil peat must have had the same origin as beds of coal, both having been peat-mosses on islands produced in the ancient sea by the earliest of the catastrophes so frequent on its bottom; which islands afterwards sinking, in consequence of other convulsions, passed, but at different periods, beneath its waters. "During a long time, the liquid of the sea possessed ingredients proper for mineralizing the

account for the intermixture of the debris of vegetables and animals with marine bodies, in many parts of the

peat under the form of coal, on the beds of which substance many stony strata, of different kinds, were subsequently formed; but its vegetable origin is always manifestly shown by the plants of various species found in the stony strata that immediately cover it. The peat-mosses formed on islands which sunk at a later period, when the liquid no longer possessed this mineralizing faculty, were covered likewise with strata of a different nature; but in these, the peat, and the wood beneath it, are found with little alteration." Geol. Travels in France, &c., Vol. i. § 199. See also Letter IV. § 21, and Journ. de Physique, Tom. xxxix. (part ii.) p. 346. 1790; xli. (part ii.) pp. 221—229. 1792; xlii. p. 233. et seq. 1793.

In a hill, in the district of Lauenstein, north of the Elbe, (described in the Geological Travels in France and Germany, Vol. i. § 360.) three beds of coal, one above the other, have been discovered, their sections appearing between those of the stony strata. These beds have evidently subsided at different periods. The lowermost rests on strata of a very hard marble containing marine bodies; this bed is separated from the next above it by strata of lime-stone likewise enclosing marine bodies. Between the second bed of coal and the third above, there are strata of sand-stone. It is obvious that this last bed has been submerged at a later period than the others; for, although precipitations of the stony strata were still taking place, the sea had lost its power of mineralizing the peat into coal: instead of the latter, we find only peat reduced to a blackish powder, preserving, however, its combustibility.

De Luc's theory respecting the islands of the ancient sea, furnishes in a variety of instances the most satisfactory explanations of the phenomena. In a reply to a memoir on fresh-water formations published in 1811, by M. Alex. Brongniart, our author remarks that this naturalist is mistaken in placing the origin of those deposits on our continents, posterior to the period of their being abandoned by the ocean; that in the same manner as coal and fossil peat, they had been formed on islands and peninsulas of the ancient sea, which owing to the catastrophes occasioned by the infiltration of its waters, had sometimes been submerged, and at other times had re-appeared above the surface.

land[1]. Several other islands, not submerged, became, by the last retreat of the sea, the summits of our

[1] The occasional intermixture, however, of marine shells belonging to the *latest* formations, with the fossil remains of terrestrial animals, presents a geological problem of no easy solution. In order to account for this phenomenon, Mr. J. A. de Luc conceives that there existed deep gulphs and mediterranean seas, in the beds of which the bones of the quadrupeds may have remained for a considerable time, having been drifted thither by the ancient rivers, or the waves of the ocean. It was then that many of the bones were covered with oysters, millepores, serpulæ, &c. which adhered to their surface in the same manner as on the coast of Naples, fragments of urns and other utensils are found beneath the waters of the sea covered with the productions of marine polypi or bivalves, or sea-worms. The same aqueous revolution must have buried all the organic bodies, terrestrial and marine, together with the forests; and hence the intermixture of the wood and osseous remains with the shells. The tracts of land were left dry by a subsequent revolution, when an universal depression of the level of the ocean took place. It is to this last revolution that our author adverts when he says, that not many ages have elapsed, since the continental parts of our globe were abandoned by the sea. See Sect. II. of this Introduction.

As an instance of the association of bones and shells, may be adduced the osseous fragments dispersed in the stratum called Norfolk crag, or upper marine formation, as described by Mr. R. Taylor, in his geological dissertation, to which reference has been already made, in Sect. II. of this Introduction. Mr. Taylor considers that these fragments are the relics of those animals which "roamed along the antediluvian shores and æstuaries, and fed amidst the forests of a former world." This opinion, however, according to Mr. J. A. de Luc, is inadmissible, inasmuch as terrestrial animals cannot inhabit a land recently covered by the ocean. Such an association of the terrestrial with the marine, can proceed only from some sudden revolution. The waters of the ocean sweeping over a great portion of the globe, drifted the osseous fragments from the dry land to the bottom of a neighbouring mediterranean sea, full of shells. Mr. Taylor adduces proofs of the

present mountains, and the principal sources of the vegetables and animals of the new continents[1].

SECTION V.

Agreement of Cuvier and Alex. Brongniart with De Luc.

The general correctness of the statement of geological phenomena, here set forth from De Luc, together with his views on the respective causes and operations connected with them, as suggested by that great naturalist, have been acknowledged and adopted by the celebrated Cuvier.

And first, that our strata (which had been fractured into masses that became ridges of mountains,) were originally formed in a liquid, in which for a great length of time no organic beings existed, is admitted in the following passage of Cuvier's "Recherches sur les

erosive power of diluvian currents exercised upon the stratum of the crag, the same probably which brought down the bones of the quadrupeds upon that stratum. The crag must have formed the bed of a shallow sea, in the vicinity of which there existed lands covered with forests, and inhabited by large quadrupeds. The great aqueous revolution above spoken of, drifted the fragments of wood and the osseous remains, and intermingled them with the shells; at a subsequent period, the level of the ocean sank, and the bed of shells, called crag, was left dry.

The same association is ascertained with respect to Piedmont, the Plaisantin, and Tuscany; and also in regard to the basins of the rivers of Russia, such as the Jaik, the Oby, the Irtish, and the Kama, which discharges itself into the Volga.

[1] The author accordingly considers Mount Ararat to have been one of the islands in the ancient sea. See Letter VI. § 18. and Journ. de Physique, Tom. xli. part ii. p. 221. et seq. (1792.)

Ossemens Fossiles:"—" The first sea was uninhabited........ It is impossible to deny that the masses which constitute our highest mountains, have been originally in a liquid state; that for a long time they were covered with waters, in which no living beings existed." He then speaks of the overturnings, the disruptions, and the fissures observable in the strata of these masses, as well as in those of more recent formations [1].

The connection established by the author between the successive changes in the liquid and successive revolutions at the bottom of the sea is recognised in the following passage:—" the displacements of the strata were accompanied and followed by changes in the nature of the fluid........ [2]."

The general connection that has been pointed out by De Luc between the formation of the strata and the history of organic bodies on our globe, is fully allowed by Cuvier in the same work. " It was," our author had said, " the organic bodies contained in our mineral strata which gave birth to geology"...... " their succession in our strata indicates a certain succession of periods in their history, connected with the formation of these strata [3]." " It is to fossil remains alone," says Cuvier, " that we owe even the commencement of a theory of the earth........

[1] See Prof. Jameson's fifth edition of the Essay on the Theory of the Earth, p. 20. The Professor has noticed Cuvier's adoption of the opinion of De Luc, that the more ancient strata, originally formed in a horizontal situation, have assumed their present highly inclined position, in consequence of subsidences that have taken place over the whole surface of the globe. Essay, &c. p. 333.

[2] Ibid. p. 11.

[3] Letter II. § 14. I. § 7.

without them we should perhaps never have even suspected that there had existed any successive epochs, and a series of different operations, in the formation of the globe [1]."

Cuvier also, agreeably to what had been stated by our author respecting the existence of organized beings, asserts that the marine animals began to exist from the earliest periods of the formation of the transition or intermediate strata, and that a long time after, the land quadrupeds appeared in considerable number.

The changes which, according to De Luc, those organized beings gradually underwent, are in like manner admitted by the French naturalist, together with the cause by which these changes were produced. "All the organized beings," says the former, "vegetables as well as animals, whether marine or terrestrial, underwent great changes, in proportion as the liquid .... varied [2]." "There has been," remarks Cuvier, "a succession of variations in the economy of organic nature, which has been occasioned by those of the fluid in which the animals lived, or which has at least corresponded with them [3]."

De Luc had observed that the organized beings, of which the remains are found in the last strata produced by the sea previously to its retreat from our continents, approximate to the species now existing, in proportion to the lateness of their appearance on the globe, and consequently to the shortness of the time during which they had been subjected to the

[1] Essay on the Theory, &c. p. 51. [2] Letter III. § 37.
[3] Essay on the Theory, &c. p. 12.

effects of successive changes in terrestrial causes [1]. Accordingly, Cuvier tells us that "the variations in the economy of organic nature, have gradually conducted the classes of aquatic animals to their present state, till at length, at the time when the sea retired from our continents for the last time, its inhabitants did not differ much from those which are found in it at the present day [2]."

It has been asserted by the author, that no human reliquiæ have been found in our strata:—and Cuvier admits, that "every circumstance leads to the conclusion, that the human species did not exist in the countries in which the fossil bones have been discovered, at the epoch of the revolutions by which these bones were covered up [3]."

De Luc, as we have seen, has adverted to the importance of the distinction which he is convinced must be made between two classes of effects, one, of

[1] Letter IV. § 39. From the most accurate observations which have yet been made in this department of natural history, the following conclusion has been drawn:—"that in proportion as we descend the vast series of deposits that overspread this portion of the earth, so do we recede, step by step, from the circle of organized beings, and from the phenomena attendant on their structure, and their adaptations." Philosophical Magazine, p. 152. August, 1829.

[2] Essay on the Theory, &c. p. 12. The similarity, however, between the fossil and living organized beings, was overstated by our author. Mr. J. A. de Luc observes, that in regard to the marine fossil shells contained in the last deposits of the ocean, the twentieth part of the different species is not to be met with in the present seas; and that with respect to the terrestrial quadrupeds of which the fossil bones have been discovered, not a fourth part of the species is now existing.

[3] Essay on the Theory, &c. p. 120.

those which had been already produced upon the earth's surface, *previously* to the existence of our continents, and the other, of such as took place upon these continents, subsequently to that period; and has carefully discriminated between the causes still in action, and those which have ceased to operate[1]. Cuvier maintains with no less confidence, his belief that "none of the agents which nature now employs, would have been sufficient for the production of her ancient works[2]."

The following important acknowledgment of a fundamental point in De Luc's theory by Cuvier may here with propriety be adduced:—"I agree, therefore, with M.M. De Luc and Dolomieu in thinking, that if any thing in geology be established, it is, that the surface of our globe has undergone a great and sudden revolution, the date of which cannot be referred to a much earlier period than five or six thousand years ago; that this revolution overwhelmed and caused to disappear the countries which were previously inhabited by man, and the species of animals now best known; that, on the other hand, it laid dry the bottom of the last sea, and formed of it the countries which are at the present day inhabited; that it is since the occurrence of this revolution that the small number of individuals dispersed by it have spread and propagated over the newly exposed lands, and, consequently, that it is since this epoch only, that human societies have assumed a progressive

[1] Elementary Treatise, § 73. Letter V. 11. Journ. de Physique, tom. xxxix. (part ii.) p. 333.

[2] Essay on the Theory, &c. p. 24.

march, that they have formed establishments, raised monuments, collected natural facts, and invented scientific systems [1]."

With regard to the classes of effects which have taken place on our continents since they were abandoned by the sea, the author had observed, that "by tracing back the action of *actual causes*, we are enabled to ascertain, with sufficient precision, the time during which they have operated, or, in other words, the time which has elapsed since the birth of our continents [2]. Such geological chronometers are unhesitatingly admitted by Cuvier:—"when," he says, "we measure the effects produced in a given time by causes still acting, and compare them with those which the same causes have produced since they have begun to act, we are enabled to determine nearly the instant at which their action commenced; which is necessarily the same as that in which our continents assumed their present form, or that of the last sudden retreat of the waters [3]."

As a particular instance of this admission of De Luc's natural chronometers by Cuvier, the effects of the sea on steep coasts may here be mentioned. "The masses," says the former, "fallen from the rocks have raised the bottom of the sea at their feet; and we now find this rampart against the action of its waters, in a state of greater or less forwardness, in proportion to the depth which it originally possessed, and to the

[1] Essay on the Theory, &c. p. 239. See likewise "Physical Proofs of the Newness of the present Continents;" and "The Newness of the Continents confirmed by the History of Nations." p. 137. et seq.

[2] Elementary Treatise, § 74. [3] Essay, &c. p. 122.

rapidity with which the rocks decay." Geol. Travels, Vol. I. § 93. This fact he had ascertained, and described in his earliest geological works; and he adduced it in opposition to the assertion of Mr. Playfair, who had stated that "on such shores, the fragments of rock once detached become instruments of farther destruction, and make a part of the powerful artillery with which the ocean assails the *bulwarks* of the land: they are impelled against the rocks, from which they break off other fragments, and the whole are thus ground against one another; whatever be their hardness, they are reduced to gravel, the smooth surface and round figure, of which, are the most certain proofs of a detritus which nothing can resist." "If Mr. Playfair," continues our author, (§ 94.) "had followed this operation more attentively, he would have seen that the gravel thus formed serves, on the contrary, to prepare for our land a new and more effectual bulwark against the assaults of the ocean. The waves, undoubtedly, impel this gravel against the feet of the rocks; but after a certain time, they leave it there; and thus, as I have already described, is formed a beach, which rises and extends itself more and more, and by degrees keeps the sea at a distance [1]." The

[1] "However correct," observes Mr. J. A. de Luc, "Mr. Lyell's statement respecting the encroachments of the sea on some parts of the coasts of England may be, let it not be supposed that all is lost: new lands are forming along other portions of the coast, and what England loses in one part, it gains in another. Mr. Lyell seeks every where for instances of destruction. Thus, at p. 290, he relates the ravages made by the sea on the western coasts of Sleswigh in Denmark, he mentions the islands separated from the continent; but he forbears stating that those submersed lands were premature conquests made by man over the ocean, insomuch that it

following passage in Cuvier's Essay on the Theory, &c. will be found in perfect accordance with De Luc's account of the phenomenon in question :—" when the coast is high, the sea, which is thus prevented from throwing up any thing, exercises a destructive action upon it. Its waves, by sapping the foundation, cause the superincumbent portion of the face of the cliff, thus deprived of support, to be incessantly falling down in fragments. These fragments are tossed about by the billows, until the softer and more divided parts disappear. The harder portions, from being rolled in contrary directions, assume the form of boulders and pebbles; and these, at length, accumulate in sufficient quantity to form a rampart, by which the bottom of the cliff is protected against farther depredations." Essay on the Theory, &c., p. 29.

The concurrence of opinion on the part of Cuvier with De Luc, as to the general nature of the operations which have been taking place since our land was abandoned by the ocean, will be seen from the following extract :—" It must, in fact, have been since this last retreat of the waters, that our present steep declivities have begun to disintegrate, and to form heaps of debris at their bases; that our present rivers have begun to flow, and to deposit their alluvial matters; that our present vegetation has begun to extend itself, and to produce soil; that our present

is not surprising that the sea should again have invaded them. The same is the case with the Zuider-See, in Holland, where the inhabitants had redeemed some lands from the sea, and enclosed them with dikes at too early a period. These lands subsided, and in consequence of a violent storm, the dikes were broken, and the sea resumed its ancient possession."

cliffs have begun to be corroded by the sea; that our present downs have begun to be thrown up by the wind: just as it must have been since this same epoch, that colonies of men have begun, for the first or second time, to spread themselves, and to form establishments in places fitted by nature for their reception." The several points enumerated in this passage are satisfactorily established in the following, and other works of De Luc.

Such is the remarkable confirmation which, the views of the author respecting the most important points of geological science, have received, at the distance of nearly fifty years, from the researches of the justly celebrated French naturalist [1].

The geological researches of M. Alex. Brongniart have led him likewise to form conclusions similar to those of De Luc. After having adduced proofs of the residence of the sea upon our continents for a considerable period of time, and shown that the presence of marine bodies at the great heights where they are

[1] In regard to the interesting phenomenon of the osseous caves and fissures, so ably described by Dr. Buckland, it would appear that Cuvier likewise adopts in a great measure the opinions of De Luc. In a communication with which he has favoured the editor, he states his belief, in agreement with our author, that the large quadrupeds sought shelter in the caverns of Germany, and that they perished there; but that this was *previously* to the catastrophe, which is the last, or rather the last but one, of those which have affected the totality, or the greatest part of the globe. Cuvier also has ascertained that the bones of which De Luc more particularly speaks, and which he conceived to belong to the white polar bear, are those of the Ursus Spelæus, an extinct species. The tracts of land occupied by the animals, were supposed by the author to have been islands in the ancient sea.

found, cannot be accounted for by tides, or incursions, and extensive inundations of the waters of the ocean, he observes that the difference of level found between these vestiges of its presence, and its highest elevation, dating from the most remote historical times, can be explained only by two classes of causes:—the lowering of the level of the sea, or the elevation of the land. "On the supposition," he continues, "that the present relative level of sea and land was produced by elevation, such elevation must have been general, since we find on all our continents abundant proofs of the presence of the ocean. Now this hypothesis is not easy to be maintained. In order that numerous points of a solid crust should be elevated, we must admit the repetition of the same cause in as many places as there are indications of the difference of levels, while a single depression of the crust of the globe at any particular point is sufficient to effect the lowering of all the seas at the same level." Mr. B. accordingly contends for the probability that the marine productions situated as he describes them, "were abandoned by the present sea, when its level was lowered, and that such lowering constituted the last of the great geological phenomena which have modified in a general manner the earth's surface in its relations of form and elevation with the seas." Tableau des Terrains, &c., pp. 93, 94. 1829.

SECTION VI.

Mosaic "Days" to be considered as indefinite periods.

The inferences to be deduced from the events and operations of which a slight sketch has been given in the preceding pages, as bearing upon the length of time which the different operations must have occupied, are fully considered in a work published by the author at Berlin, in the year 1799 [1]. From that, and others of his works, a summary will now be given of the arguments adduced by De Luc in vindication of a more extended interpretation of the word "day," as used by Moses, than that by which it is limited to a period of twenty-four hours.

Arguments in support of that Opinion.

A slight study [2] of the mineral strata of which the observable mass of our continents is composed, is sufficient to convince us that the globe has existed for a very considerable length of time. The succession of the genera and species of the strata;—that of the remains of organic bodies contained in a portion

[1] "Lettres sur l'Education religieuse de l'Enfance." This work, which contains the most luminous views on the important subject of which it treats, has not yet been translated into our language. It was dedicated, by permission, to the King of Prussia, 18th Dec. 1799.

[2] Lettres sur l'Education, &c. p. 92, et seq.

of them, changing also their species at the same time that those strata lying above others which had not as yet contained them, changed theirs;—lastly, the catastrophes which they have all undergone, not once but a number of times, and in periods necessarily very distant from each other, irresistibly demonstrate that truth. So that if we add only six solar days to the Mosaic chronology from Adam, the phenomena of the earth will in reality be found in direct contradiction with that chronology. The theologians who, in order to remove this difficulty, without abandoning the received opinion respecting the meaning of the "days" mentioned in the first chapter of Genesis, have had recourse to the power of the Creator, not being acquainted with those phenomena, have thus strengthened in many minds, otherwise disposed to believe in Revelation, a favourite argument of unbelievers. The power of God, indeed, has no limits; but it does nothing in vain; it would not then be employed, without any object, in enclosing bodies, similar in every respect to the remains of organic beings, within the masses of stone which constitute considerable chains of high mountains; and in stones which were to appear as having been first formed in continuous strata, then fractured and dislocated at different periods of time, very distant from each other, although the causes of those catastrophes are apparent. To speak in general, when we witness manifest effects of second causes; effects which, by their nature, must have required a great length of time for their production,—it is not in our power to believe that the causes and their effects have been produced at once by a single act of the supreme will. It is, therefore,

necessary to have studied the earth, together with the causes which operate on its surface, in order to be enabled to appreciate and combat the objections of the naturalists who attack the Mosaic history; for otherwise a force may be allowed to such objections which they do not possess.

Geology, observes De Luc[1], would have rendered the objection in question unanswerable, had the word "day" been susceptible of one sense only; but he refers to his earliest work for proofs that, making use of our translations only, and following the application of the word "day" in different parts of Genesis, that term was frequently employed to designate periods of which the evening and morning expressed the termination of one, and the beginning of another, without any determinate limits. He had moreover ascertained from persons deeply conversant in the Oriental languages, that such was likewise the case in the Hebrew text; and afterwards, at Göttingen, Prof. Michaelis assured him that he was entirely authorised to adopt that interpretation, which the professor even strengthened by new arguments.

In agreement with this view[2], he had already in that first work divided the physical history of the earth into *two great periods* very clearly discernible in our monuments:—the one anterior to the birth of our continents as dry land;—which forms the epoch of the flood described by Moses; the other posterior to that event. He had at the same time remarked that the extent of the first period was not determined in the text, because it comprised those six "days" of

[1] Lettres sur l'Education, &c. p. 93.

[2] Ibid. p. 94. See likewise Letter V. § 11, of this Collection.

the first chapter of Genesis. That chapter then indicates only the order according to which some things in nature, respecting which it was important for men to know that the origin had depended on successive acts of the will of the Creator, have begun to exist. This is all that we find in that chapter; but the study of nature enables us to ascertain that the *second causes*, established likewise by its author, were to continue their operations, for a considerable length of time, in order to prepare the earth to receive and maintain its various inhabitants in the succession which is indicated by the inspired writer. Now, although we have proceeded so far as to be able to determine respectively those causes, circumstances have so considerably changed upon the globe, by their very operations, that facts are wanting, in order to assign the duration of those operations between the different acts of the Creator specifically declared. Such is the reason why the duration of the first of the two great periods of the history of the earth remains undetermined for us. Up to the creation of man, the Book of Genesis points out to us successive acts only of the Divine will. But as soon as the intelligent being to whom God condescended to reveal himself, appears upon the earth, there commences a positive chronology, specified thenceforth by days, months, years, and successive generations of men. It is *before* the epoch at which the Mosaic chronology begins, that those effects have taken place the monuments of which distinctly indicate that high degree of antiquity of the earth, which constituted the only specious objection against the narrative of Moses, as long as the six "days" were erroneously interpreted. Accordingly it may be remarked,

that the most strenuous advocates for the supposed literal interpretation, are the very writers who are desirous to represent as mythological the description of the primitive world by the inspired penman[1].

The chief arguments advanced by the author against the interpretation which would restrict the Mosaic periods within the limits of an astronomical day, are the following:—first[2], we may remark, in the first chapter of the Book of Genesis, an opposition between the supposed fact of days of twenty-four hours, which bear a relation to the earth's revolutions in presence of the sun, illuminating it, and the circumstance that during the three first of those days, there is as yet no mention made of the sun, but only on the fourth; which circumstance alone had induced some interpreters to consider this history of the creation as divided into six periods of indefinite length.

In illustration of the author's argument, it may be remarked that the purpose of the creation which took place on the fourth day, was the separation of the day from the night in the literal sense of those words;—was, in fact, the formation of a day of twenty-four hours. Before that time, therefore, no such period as that of a natural day could have existed. This purpose is apparent from the words of the 18th verse: "to divide the light from the darkness." Wherefore the words morning and evening in the preceding verses must be considered as allegorically expressive

[1] Lettres sur l'Education, &c. p. 95. This remark was meant by De Luc to have its chief application to certain sceptical writers in Germany.

[2] Lettres sur le Christianisme adressées à M. le Pasteur Teller, p. 55, et seq.

of the beginning and ending of periods of a different kind; and the word day in the 5th verse should be understood to designate merely in general a period of light of a very different length from that of a natural day [1].

Another consideration would necessarily lead to the same inference with that of the author in respect to the length of the Mosaic " days," namely, that [2] they are designated by *evening* and *morning*, an expression which does not indicate twenty-four hours; for that space of time would be reckoned from *evening* to *evening*, or from *morning* to *morning*. And in the 23d chapter of Leviticus, we have a proof that in the language of Moses such an interval would be so expressed. Speaking of the day of atonement, the tenth day of the seventh month of the year, and consequently meaning a day of twenty-four hours, the writer defines it thus in the 32d verse: " The ninth day of the month at even, from even to even, shall ye celebrate your Sabbath [3]." And as, moreover, morning and evening are expressions used to denote likewise the *beginning* and *end*, either of a life, or of a certain period, there can be no doubt that it is necessary, without reference to any thing but the immediate sense contemplated by the inspired writer, to take for indefinite periods the " days" in question.

[1] Accordingly Philo Judæus calls " day" a period of light, Gen. i. 5; and on Deut. iv. 4. היום *ἀπείρατος καὶ ἀδιεξίτητος αἰών*. Aben Ezra, (remarks a learned Orientalist) in his commentary on the account of the Creation, asserts, that יום allegorically expresses a revolution, (גלגל).

[2] Lettres sur le Christianisme, &c. p. 56. [3] Ibid. p. 56.

In regard to the indefinite length of those periods[1], excepting in so far as they are determined by the nature of the case, we meet with a proof in the subject itself, as early as the fourth verse of the second chapter: "These are the generations of the heavens and of the earth when they were created; in the *day* that the Lord God made the earth and the heavens." The translators were well aware that a day of twenty-four hours in this place was not spoken of, since the term here designates the entire six; accordingly we read in the French translation: "*quand* l'Eternel Dieu fit la terre et les cieux[2]."

It could be proved[3] by many other examples, that

[1] Lettres sur le Christianisme, &c. p. 56.

[2] In Coverdale and Mathew's Translations of the Bible, the word "day" in the above passage is rendered by *time*. "Eo *die*—id est, *quandò*," observes Le Clerc in his commentaries, "nam hîc *dies* sex dies propriè dictos complectitur. *Dies* tempus in genere passim dicitur." In a work held in high estimation by the Gallican Church, entitled, La Genèse traduite en François, avec une explication tirée des saints Pères et des auteurs ecclésiastiques, 1682, the following note is annexed to the verse here quoted: *Au jour*, &c.—c'est à dire *au tems*. Le mot de jour se prend souvent dans l'Ecriture pour le *tems*. Et ainsi il marque en ce lieu l'espace des six jours, pendant lesquels le monde a été créé." The word "day" has been applied to the seventh day, and not to the preceding six; (Comparative Estimate of the Mineral and Mosaical Geologies,) such an application however, is in contradiction to the received sense of the passage. And if the word "day" does not mean here the seventh day, then that term may be taken for a period of indefinite length generally; for "the heavens and the earth," not having been created in an astronomical day, we are at liberty to exclude the literal sense in our interpretation of the six Mosaic days, and to consider them as periods of undetermined duration.

[3] Lettres sur le Christianisme, &c. p. 57.

this word is employed in Hebrew to denote any period of time whatever, without any restriction except the nature of the circumstance; but one other instance will suffice to make this evident; it occurs in Leviticus, chap. xxv., where, amongst divers ordinances prescribed by God to Moses for the time when the Israelites should be settled in the land of Canaan, we find the following, verse 8: "And thou shalt number seven Sabbaths of years unto thee, seven times seven years; and the space[1] (days) of the seven Sabbaths of years shall be unto thee forty and nine years."

Lastly[2], a sufficient proof how familiar this sense of the word was to the Jews, is that they transplanted it into the Greek language. St. Paul, in the 3d chapter of his epistle to the Hebrews, verse 7—9, says: "Wherefore, as the Holy Ghost saith, to-day if ye will hear his voice, harden not your hearts, as in the provocation, in the *day* of temptation in the wilderness: when your fathers tempted me, proved me, and saw my works *forty years*[3]."

[1] *Jours* is the word used in the French translation, agreeably to the original.

[2] Lettres sur le Christianisme, p. 58.

[3] In this passage, "*in the day*" is but the Hellenistic version of ביום, which יום is expressly here said to have occupied forty years. Some writers conceive these *Yamim* to have been *αἰῶνες*, which imply ages of immeasurable duration, together with the created Beings existing in them during their course, and the seventh day or *αἰὼν* to be that now passing; and imagine the eternity of the last day to be described as reaching *εἰς τοὺς αἰῶνας τῶν αἰώνων*. In this idea they are corroborated by the epistle to the Hebrews, e. g. I. 2. XI. 3. in which the term *αἰῶνες* appears to refer to the successive periods of the creation. See Macknight's Commentary, and F. M. Macnab's

A modern critic[1] has objected that the word "day," in instances like those adduced by the author, "is employed only to produce an impression of present occurrence or of actual arrival," without reference to length or continuance of time. Such a view, however, seems to come short of the truth. In all similar passages the word likewise necessarily suggests the idea of *duration,* though it may be *irrelevant* to the writer's object to advert to it. Thus in Hebrews iii. 7—9, the word suggests the sense of a period of a natural day, employed metaphorically, since a term of forty years is spoken of. It was for the purpose of adducing the word in this metaphorical sense, that De Luc has quoted the passage.

The following passages may here be added:— "Hide not thy face from me, *in the day when I am in trouble.*" Psalm cii. 3. ("*time* of my trouble"—early Geneva Bible.) "Thy people shall be willing *in the day* of thy power." Psalm cx. 3. ("Thy people will be very willing *in the time* of showing thy most mighty power." Bishops' Bible.) "And *in that day* shall the deaf hear the words of the book." Isaiah xxix. 18. ("When the Messiah shall come." Bishop Wilson's Bible.) "Thy *day* is come, the *time* that I will visit thee." Jerem. l. 31. In the Septuagint, cap. xxvii. 31. the word *time,* is rendered in the same passage by *καιρός.*

It would seem that in these passages, which, as is evident, might be easily multiplied, the term "day" is

"Theory of the Moral and Physical System of the Universe." p. 10, et seq. Edinb. 1817.

[1] See Mr. Granville Penn's Comparative Estimate of the Mineral and Mosaical Geologies.

expressive not only of the actual arrival of the time, but also suggests the idea of the whole period adverted to[1]: as in the instance of St. John, in which our Saviour mentions Abraham, as rejoicing by anticipation to have seen his day. On this passage it may be observed, that as the Jews expressed the times of the Messiah by the plural form, "days of the Messias," and our Saviour adverted to them by the singular form "day," (τὴν ἡμέρην τὴν ἐμὴν) it is evident, that in Jewish phraseology the one form was equivalent to the other, consequently, that this *yôm* alluded to *the whole* dispensation of our Saviour.

In the author's Correspondance Particulière entre M. le Docteur Teller et J. A. De Luc, Hanovre, 1803, he remarks, that the seventh Mosaic day must evidently be considered as a period of rest of indefinite duration .... as a period which commences after the creation, and is not to terminate until after a great change in the order of things. He here adverts to the first, and second or "eternal sabbath" mentioned by Bacon, in his Confession of Faith, whose authority he adduces in favour of his interpretation of the seventh day[2]. That we are led to such

[1] This criticism is corroborated by the following passage:—Posset exponi *dies*, per totum tempus Novi Testamenti, à nativitate, aut ab ascensione Christi, usque ad finem seculorum. Hæc expositio absurda videri nemini debet: cùm œconomia Novi Testamenti plus semel veniat nomine diei. *Abraham desideravit videre diem Domini*, id est, beata ista tempora Novi Test. Joh. viii. 56. Et *dies salutis* dicitur, quoniam hæc tempora, et Judæis et Gentibus, salutem adferunt. Es. xlix. 8. Ps. cxviii. 24. 2 Cor. vi. 2. Johan. Braunii Dissert. de Adolit. Suffitus. Ugolini Antiq. Sacr. Thesaurus, p. 786.

[2] "The laws of nature, which now remain and govern inviolably till the end of the world, began to be in force when God first rested

a conclusion by the passage itself, does not, in the view of the author, admit of a doubt. After having designated by *evening* and *morning*, the "days" or periods of the terminated works, when the sacred historian comes to the period (or day) of rest, at the commencement of the second chapter, he thus alters his form of expression. "And on the seventh day God ended his work which he had made: and he rested on the seventh day from all his work which he had made:" a remarkable distinction between that period which was then beginning only, and those which had successively terminated. "It is in this sense," observes De Luc, "that Bacon understood the 'day of rest' of the Creator, without even any reference to the preceding 'days.' When God instituted the sabbath among the Israelites, he gave it to them as a sign of his covenant with them, and it became the emblem of his 'rest' on the 'seventh day,' or the seventh of the periods recorded in the book of Genesis [1]."

Our author's mode of reasoning from this remarkable passage of Bacon, appears perfectly just. God's

from his works, and ceased to create. Notwithstanding God hath rested and ceased from creating since the first sabbath, yet, nevertheless, he doth accomplish and fulfil his divine will in all things ...... as fully and exactly by providence, as he could by miracle and new creation ...... so that the ways and proceedings of God with spirits are not included in nature; that is, in the laws of heaven and earth; but are reserved to the law of his secret will and grace: wherein God *worketh* still, and resteth not from the work of redemption, as he *resteth* from the work of creation: but continueth working till the end of the world; what time that work also shall be accomplished, and an eternal sabbath shall ensue."

[1] Correspondance Particulière, &c. pp. 8. 10.

rest from his work of creation still continuing, the word "day," as descriptive of the duration of that rest, must necessarily be taken in an indefinite sense; and hence we may further conclude that the six preceding "days" indicate, in like manner, periods of undetermined length.

These are the principal arguments adduced by De Luc in defence of the interpretation which he has adopted. Some further illustrations and remarks on this interesting point will here be offered by the editor in confirmation of his views.

It had been objected against the author, that he ought not to contend respecting the direct meaning of Genesis with those who are acquainted with the original language, in consequence of his own ignorance of it. He defended himself from the objection, by alleging that no difference of opinion existed on this head, excepting in regard to the word "day" in the first chapter of that sacred book; and that the question in point had no exclusive reference to the Hebrew tongue. The metaphorical or secondary sense of the expression, he observed, is adopted in all languages; and, as an immediate instance, he quotes, in his "Correspondance Particulière," &c. p. 7, Dr. Teller's own expression: "although I have now reached the *evening* of my life." It seems, in fact, a gratuitous assumption to maintain that the term is *not* to be taken figuratively in the first chapter of Genesis; especially when it is considered how peculiarly favourable the Hebrew language is to the metaphorical use of words.

Since geological phenomena attest that many ages have elapsed between the first *fiat* of the Almighty,

and the appearance of man upon the globe, the following alternative seems to present itself; either we must admit that the Mosaic "days" are indeterminate periods, or it must be supposed that the greater number of fossils were formed before the Mosaic creation—an hypothesis which appears contrary to the express declaration of Scripture. When we read in the third verse of the second chapter of Genesis, that "God blessed the seventh day, and sanctified it: because that in it he had rested from all his works which God created and made," and connect these words with the expression in the fourth commandment, "In *six days* the Lord made heaven and earth, the sea, and all that in them is," we seem precluded from having recourse to the hypothesis recurred to by some of an anterior state of things, the existence of which would account for the greater part of fossils found in our mineral strata[1].

[1] That the hypothesis, noticed in the text must be rejected from considerations unconnected with scripture authority, will appear from the following remarks, extracted from the Bibl. Univ. tom. xviii. (Sciences et Arts,) p. 58. 1821: "Some have imagined that the earth has had two distinct existences, separated by the chaos spoken of in the second verse of the first chapter of Genesis. This opinion, however, is contradicted by natural history. The study of the fossil organized bodies exhibits a series of changes which are connected with each other. Thus amongst the most ancient marine fossil shells we discover several genera which still live in our seas; we follow their history through all the mineral strata until we arrive at those which inhabit the present ocean. Although many genera are extinct, and others appear, there are permanent genera which serve as links of connection between the different epochs. At one of the epochs of the existence of marine animals, oviparous quadrupeds began to exist; afterwards the viviparous and terrestrial quadrupeds appeared, and lastly man, together with new species of

Should it be objected that the Hebrew word in the latter passage is, עשה (to arrange, to complete) and not ברא as in Gen. i. 1, it may be observed in reply, that in some parts of the Hebrew Bible these expressions are equivalent, and that the former word includes not unfrequently the whole process of creation collectively, as in Exod. xxxi. 17; Psa. cxlvi. 6; Jer. x. 12; 1 Chron. xvi. 26; Nehem. ix. 6; Psa. xxxiii. 6; xcvi. 6; cxxi. 2; cxxiv. 8; cxxxiv. 3; and many other instances, which might be produced. But those expressions also occasionally occur together, as in Isaiah xliii. 7; xlv. 18, &c.

If then it can be shown that the word "day" is sometimes employed in Scripture in the sense of an indefinite period of time, it becomes requisite to adopt that interpretation of the word which is alone compatible with the phenomena.

quadrupeds ·········· We can ascertain a succession in the revolutions of the globe, the last of which affected the human race ············ and we nowhere perceive a *saltus* indicating two well defined and distinct existences of our globe. An universal state of solution immediately followed the creation of the earth in its unshapen state, and it was then that in consequence of its rotatory movement, it assumed a spheroidal form flattened at the poles and jutting out towards the equator; the different revolutions of which we perceive the traces at its surface, took place at subsequent periods. We accordingly find nothing in natural history to countenance the conjecture of a perfect condition of the earth anterior to, or intermediate between the successive revolutions which have brought it into its present state." Mémoire sur la chaleur intérieure de la terre, par M. J. A. de Luc, neveu.

Ancient and Modern Authorities.

Some of the most pious and learned men of ancient and modern times have coincided in the views of De Luc on this subject. A few authorities will here be brought together.

ORIGEN conveys in forcible language his opinion that the Mosaic "days" are not days of twenty-four hours:—"Cuinam quæso sensum habenti convenienter videbitur dictum, quòd dies prima, et secunda, et tertia, in quibus et vespera nominatur, et mane, fuerint sine sole, et sine luna, et sine stellis: prima autem dies sine cœlo."

St. AUGUSTIN expressly says that the words "the evening and morning were the first day," are not to be understood of the termination and commencement of an ordinary day; (de Civit. Dei, Lib. I. cap. 29.) and in the same work he further states that it is very difficult, nay, impossible to conceive, much more to set forth the nature of those days: "Qui dies, cujusmodi sint, aut perdifficile nobis, aut etiam impossibile est cogitare, quantò magis dicere."

That BEDE was likewise of opinion, with other interpreters, that, in scripture language, a day is not always to be restricted to a period of twenty-four hours, would appear from his annotation on the latter part of the fifth verse of the first chapter of Genesis: "and the evening and the morning were the first day;"—"fortassis hic diei nomen," he observes, "totius temporis nomen est, et omnia volumina seculorum hoc vocabulo includit."

M. D. Frayssinous, bishop of Hermopolis, after observing in his able Défense du Christianisme, Vol. I. (1826,) that Duguet [1], one of the most learned Scripture commentators of the last century, explains the Mosaic "day" as signifying simply an indefinite time, or epoch, adds that there is nothing in that opinion contrary to sound doctrine, and that it is entertained by several divines.

The opinion of Prof. Michaelis has already been adduced. Mr. Faber, in his learned "Treatise on the Patriarchal, Levitical, and Christian Dispensations [2]," has ably advocated the more extended interpretation. "Nothing," he observes, "can well be more indefinite than the term which we translate by the English word *day* ...... in truth the term *abstractedly* would be more accurately expressed by the word period than by the word *day:* for the context alone can determine, what specific period it may describe in any particular passage."

Similar conclusions respecting the duration of the Mosaic "days" were formed by Mr. J. Townsend in his "Vindication of Moses." "In perfect conformity to prophetic language," he says, "the term *day* may be referred to *period* in general, without meaning to restrict the word to its present acceptation." Vol. I. p. 41 [3].

[1] Explication de l'Ouvrage des six jours, ou Histoire de la Création. One vol. duodecimo, 1731.

[2] Vol. I. p. 112.

[3] "Notum est....... *Diem* aliquando a prophetis sumi pro anno, veluti apud Danielem cap. ix. ubi septuaginta hebdomadæ, adeòque quadringenti nonaginta *dies*, ponuntur pro tot *annis*. Vide quoque Numerorum iv. 34. et Ezek. iv. 6."

"*Dies* sumitur a prophetis pro trecentis sexaginta annis, veluti

The following remarks on this subject, extracted from "Thèses sur la Création du Monde," maintained at Geneva, in the year 1809, are deserving of consideration. "The word *yôm*, day, does not always carry with it the idea of an ordinary day of twelve or twenty-four hours; in certain cases it is taken figuratively......... Among the Jews it was customary to say day of summer for the whole summer, and day of harvest for the whole harvest season. Let us further observe, that the literal sense of *yôm*, is not that of an astronomical day, but a day of twelve hours. The sacred writers, when they speak of a day of twenty-four hours, generally designate it by a periphrasis; they say *a day and a night.* Gen. vii. 12; Jon. i. 17, &c. If the authority of the ancient cosmogonies can add any weight to what we have now said, we shall remark that several nations have preserved the idea of a succession of times more or less long for the epochs of creation, and that not one of them has adopted the idea of days, in a literal sense, although they consecrated the belief of six spaces or periods of time." The author of the "Thèses" here alludes to the doctrine held respecting this subject by the ancient Etruscans, by the Persians, and the Hindoos.

The Etruscans, according to SUIDAS, held that God, the author of the universe, employed 12,000 years in all his creations. In the first chiliad, or 1000 years, God made heaven and earth; in the next, the firmament which appears to us, calling it heaven; in the third, the sea and all the waters that are in the earth;

quando tres dies cum dimidio ponuntur pro mille ducentis sexaginta annis. Dan. vii. 25. Ap. xi. 2." JOHAN. BRAUNII Dissert. ut suprà.

in the fourth, the sun, moon, and stars; in the fifth, every volatile, reptile, and four-footed animal in the air, earth, and water; in the sixth, man [1]. The creation of the world, according to Zerdusht or Zoroaster, occupied 3000 years: at first the heavens were created—then the waters—then the earth—then the plants—then the animals—then man, constituting in all *six* periods [2]. In the institutes of Menu, the days of creation are mentioned as periods of some thousand years; and even a day and a night of Brama is by mythologists extended to an inconceivable duration [3].

The editor has great satisfaction in being permitted to adduce the high authorities of the Rev. SAMUEL LEE, late Professor of Arabic, and present Professor of Hebrew in the University of Cambridge, and of Dr. WAIT of the same university, in favour of the indefinite and metaphorical sense of the word.

"Such a sense," observes the Professor, "is fairly to be collected from Numb. xxviii. 26—*the day of first-fruits.* We have in BUXTORF's Great Lexicon, 'יוֹמָא-יוֹם *dies: latè* sumptum est Tempus, *et Synecdochicè Annus.*' This the examples will bear out. The compilers of [4] the SEVEN SEAS state that '*Ròz* [5] is used in the sense of *Ròzgàr (time)* which is an ap-

[1] For coincidences of ancient traditions with the Mosaic account of the creation, see Philip Howard's Scriptural History of the Earth and of Mankind, Letter I. with the notes and illustrations.

[2] BAUER's Mythologie der alten Hebräer, from KLEUKER's Zendavesta.

[3] See WILSON's Sanskrit Dictionary on the word *Kalpa.*

[4] Haft Kulzum, a valuable Persian Lexicon.

[5] The Persian of *yōm* or *day.*

pellation intimating opportunity (i. e. καιρὸς,) as they say, this is the time (season, &c.) of such an one.' In this case, therefore, it is indefinite. It is added, that the word is used 'in the sense of *yōm*, which is expressed also by *nihar* in Arabic.'"

"Mr. Granville Penn," Dr. Wait remarks, "is not sanctioned by any positive authority in restricting יום to the sense to which he confines it in the Cosmogony: for, conformably to the genius of the Semitic, and indeed of most Oriental languages, the word, as well in its singular as in its plural form, often passes from its primary signification to an extended metonymical sense, like ἡμέρα and *dies* in the classical page:—which fact being proved by the Psalms, the Prophetic Books, and the Hebraisms of the New Testament, Mr. Penn cannot be authorised in excepting Genesis from the admission of its more general force. He moreover affirms, that it 'may be used, as the commencing point or epocha of a great and undetermined period,' but that it 'will ever remain distinct from the flux and progress of that period.'

"The incorrectness of this assertion may be proved by a multitude of passages; for instance, *the day* of salvation is called עת רצון, *the accepted time* in Isaiah and the New Testament, and עולם הבא by the Jews in general; consequently these terms must not only denote 'the commencement,' but 'the flux or progress,' of the *whole* period of the Christian dispensation.

"In like manner, the *day* of destruction—of vengeance—of wrath—of slaughter—of visitation—of small things—of drought—of distress—of trouble—of ad-

versity, &c. &c. cannot be confined to the commencement of these periods, but must necessarily be understood of their entire continuance [1].

"Not contented, however, with this affirmation, Mr. Penn avers, that the word means '*actual time, or time impending*,' but never '*time retrospective*.'

"What then is the meaning of יום ירושלם in Psalm cxxxvii. 7? For as this Psalm was written after the destruction of Jerusalem, and the deportation of its inhabitants to Babylon, *yōm Yerusālām*, if it has any definite force, can ONLY be '*time retrospective*.' Other examples of its *retrospective* sense may also be seen in Josh. x. 12; xiv. 11; 2 Sam. xxii. 1; 1 Kings ii. 8; Esth. ix. 1; Ps. xcv. 8; Isa. ix. 4; Lam. i. 12; ii. 1, &c. So in *Psa.* ii. 7, either היום must have a *retrospective* meaning,—or a *precise point of time*, when Christ, (whom we assert to have been begotten before all worlds) *commenced to exist*, will be asserted according to Mr. Penn's canon.

"Among other instances, Mr. Penn endeavours to substantiate his argument from *Zach.* xiv. 7. In this he seems to be equally unfortunate:—first, because יום אחד (as Rosenmüller has shown) imports a *dies sui generis*,—one, to which no other can be compared [2],—which is distinctly proved by its description, that it is *neither day nor night*, or, accord-

[1] "In 1 *Kings* viii. 59. (דבר יום ביומו, which our translators have well paraphrased, '*as the matter shall require*,' and Luther rendered, '*ein jegliches zu seiner* ZEIT,') the indefinite force of יום cannot be denied."

[2] "ביום ההוא in verses six and eight, is rendered by Luther '*zu der zeit*:' ביום and מיום must be *necessarily retrospective*, wherever they occur."

ing to the paraphrast, neither *like* to day, nor *like* to night. Jerome calls it '*una dies atque* PERPETUA, nequaquàm sibi luce et tenebris, die et nocte, succedentibus.'

" Secondly, Mr. Penn is unfortunate, because the whole chapter, particularly verse 9, demonstrates it to be a *considerable period*, which the words, 'for it will come to pass, that at eventide there will be light,' still further corroborate, that vespertinal light prophetically relating to the universality of the Gospel in the latter part of this symbolical *yōm*.

" In support of the inferences which he elicits from the eventide in this passage, he quotes Ezek. vii. 10, where the morning is also mentioned. Hence he argues, that 'the primitive signification of the term still holds its simple ground:' that 'it denotes definitely and exclusively the *actuality* or *presence* of a time, but it does not denote indefinitely or inclusively continuation or length of that time:' that 'it is employed only to produce an impression of present occurrence or of actual arrival.'

" This passage, however, is singularly inimical to his theory; not only because the day, of which the beginning is by a just metaphor styled the morning[1], is in the 12th verse denominated *the time*, (העת) but still more so, because the context proves the prophet's reference to be to a lengthened *period* of calamity.

[1] " In *Ezek.* vii. 10, the word is הַצְּפִירָה, which SIMONIS (Ed. EICHHORN) thus interprets, '*fatum, malum extremum,* propriè *intortum,* q. d. *intortus calamitatum cinnus,* et quasi *rete*:' hence, the received translation, resting hypothetically on the Chaldee sense, is uncertain."

Consequently, the arguments, which Mr. Penn would establish on the terms *morning* and *evening* are futile and invalid, and may be subverted by the merest tyro in Oriental phraseology. Literally and primarily, they are indeed parts of the day; but figuratively and secondarily, they become by an easy metaphor commencements and terminations of periods.

"In this respect the scriptural language is uniform: and it is obvious to reason, that if *a period*, whatever be its length, be metaphorically called *a day*, the analogy of metaphorical diction will require the beginning and close of such a period, to be expressed in terms bearing a self-evident relation to that by which the period itself is designated ; or in other words, that as the *boker* and *erev* (or morning and evening) are component parts of *the day*, when the term day itself is figuratively applied, it will require these to express the opposite parts of that, of which *yōm* is the metaphor. On this principle, we read of the evening and morning of the cosmogonical *yōm;* on this principle, in some passages, which compare human life to *a day*, we read of its morning, its noon, and its evening, and occasionally observe its close appropriately designated by the night: hence also, the final judgment being called the great *day* of the Lord, we read of the morning of the resurrection.

"Mr. Penn affirms, likewise, that יום is not synecdochically accepted *as a year*.

"To support this assertion he quotes[1] Numb. xiv. 34, and Ezek. iv. 6; but these authorities are positively opposed to him.

[1] "Cf. Michaelem in Suppl. p. 1066."

They define the norm of computing the divine judgments to be יום לשנה, notwithstanding which most definite expression, he strangely asks, 'in which of these passages does the word *day* denote a natural year?'

"It is answered—in neither, according to the *primitive* force of the word, but most assuredly in both, according to its metaphorical sense and the direct affirmation of the passages; nor is it improbable, that from this prophetic norm the term became extended to the signification of this period. We can, however, desire no stronger evidence than that, with which the seventy weeks of Daniel supply us [1].

"The period of the final judgment is also called יום, which, Mr. Penn says, 'will begin upon the world, like all former days, but will not end, as all former days have ended. The term is exclusive of the duration, which shall follow. It is the actuality of its arrival alone, as a *punctum temporis*, to awaken religious apprehensions, that is denoted by the word day.' *How does Mr. Penn know, that the day of judgment will begin like all former days? by what authority does he pronounce the term exclusive of the duration?* The Jews imagine that it will be of considerable duration, notwithstanding which, in accordance with prophetic language, they call it היום, or in the Rabbinical dialect אותו היום [2]. The Arabs believe the same, and call it not only *yōm*, but eternal life, and *the everlasting day*. St. Paul uses ἡμέρα in a similar sense, and in *Rom.*

[1] "Simonis adduces *Ps.* xviii. 19; l. 15; *Is.* ix. 3. &c. to prove, that it also means time in general."

[2] Cf. Bereshith Rabba, 34. 33. 4.

xii. 12, contrasts the Mosaic dispensation under the figure of νύξ, with the Christian under that of ἡμέρα, in interpreting which every unprejudiced person must admit, that νύξ expresses the *whole* period of the Mosaic, and ἡμέρα the whole period of the Christian:—if then יום or ἡμέρα so frequently involves in itself the idea of a long duration, may it not be legitimately applied both to the creation and to the final judgment, without necessarily confining the period to that of a natural day? But Mr. Penn urges, 'the Son of Man shall come in a day and hour, when ye look not for him:—who understands the words day and hour, to denote and include the eternity, which he is sensible will follow?'

"Here it is but necessary to remark, that the *day and hour* are Hebraisms used to express *time*, that the terms are frequent in the Evangelists, and that in Mark xiii. 13, these are called καιρός: hence, the *day* of the Son of Man not merely refers to his second advent, but also to the period of that judgment, which will be consecutive to it. For, no one aware how widely the corresponding term is used [1] by the Arabs, and who has examined its extensive force among the ancient Hebrews, can dispute these philological assertions.

"I have now arrived at the main question. If in other instances יום has this figurative sense, and if geology and philosophy in general oppose the idea, that the process of the creation was completed in six natural days, are we, when observing the fuller sense of the word in passages not to be disputed,

[1] "The Hamasa contains innumerable instances of this fact."

authorized in confining the six ימים of the cosmogony to six *natural days?*

"SCHOETTGEN, in Acts ii. 17, has adduced the Jewish legend or opinion, that each *yōm* occupied 1000 years[1], whence the Jews computed six millennaries before the advent of the Messiah, whom they expected ביום שתיתאי *in the sixth yōm,* i. e. anno 6000—assigning the whole of the seventh *yōm* or millennary to his reign.

"Now, as GLASSIUS and others have shown, that where human properties and periods of time are predicated of the divine being, the language is necessarily anthropopathetical; connecting the Jewish opinion cited by Schoettgen, with St. Peter's assertion in Ep. 2. ch. iii. 8., we may without violence suppose, that יום was simply a term expressive of each period of the creation, without actually defining the period of its continuance.

"If so, the six ימים were indefinite epochs. In corroboration of this, the first chapter of Genesis details the six ימים, during which the process advanced to its perfection, but in the second, at verse 4, we read of the creation of the heavens and the earth, *in the day or at the period* (ביום) when the Lord God made them: therefore these six ימים must be comprised in this individual יום, and the term must imply an indefinite period.

"Mr. Penn, however, argues that they must have been *natural* days, because each had its ערב or evening, and בקר or morning.

"This objection has been already refuted, because

[1] "Cf. Zohar. in Gen. 13. c. 52."

the *erev* and the *boker* were necessary to preserve the uniformity of the metaphor, and therefore yield no evidence that the *yōm* was a *natural* day.

"Although in Daniel viii. 14. 26. and in Exodus and Leviticus, the νυχθήμερον be, as it is urged, implied by the *erev-boker*, the inference, that it imports the same in the first chapter of Genesis amounts to nothing, because the real question is,—not whether the *erev* and *boker* are ever expressive of a day of twenty-four hours,—but whether the *yōm* in the cosmogony, of which the *erev* and *boker* are parts, be predicated of a *natural* day, or metaphorically of an *indeterminate* period.

"When, therefore, we consider the stupendous work of the creation, it is consentaneous to sound criticism to presume, that if instances occur, in which יום is invested with a wider signification than that of the ordinary day, in which it expresses periods of time not defined by the passage, it must *à fortiori* have possessed this more ample and enlarged sense in the first chapter of Genesis.

"The very words ויהי ערב ויהי בקר יום give the idea of successive periods, and mark the *erev* as the commencement, and the *boker* as the termination.

"From which collective reasons I have no hesitation in believing, that יום in the first chapter of Genesis referred to a period consisting of a length not to be determined."

Connection between the Mosaic narrative of the Creation and Geological Phenomena.

But further:—while the first chapter of the Book of Genesis sets forth a *certain order* of operations which have taken place in periods of indeterminate length, that very order, up to the first existence of man, is manifested by geological phenomena.

That in the following Letters, the conformity of geological monuments with the sacred history of the creation may not escape the reader's observation, the author has divided the series of physical operations which resulted from the introduction of light, into *six periods*, until the appearance of *man* upon our globe.

This striking agreement, first pointed out by De Luc, is acknowledged in the valuable work of Mr. Parkinson. After observing that the formation of the exterior part of the globe, and the creation of its several inhabitants, must have been the work of a vast length of time, and have been effected at several distant periods, he thus continues:—" In the first of these periods, the granitic and other primary rocks were separated from the water. (*Gen.* i. 9.) That this separation took place, as is stated in the Scriptural record, previously to the creation of vegetables and animals, is evident from no remains of any organised substance having ever been found in any of these substances. In the next period we are informed by Scripture, that the creation of vegetables took place, (Gen. i. 12.) Almost every circumstance in the situation and disposition of coal accords with this

order of creation. The creation of the succeeding period was that of the inhabitants of the water and of the air. (Gen. i. 20.) In agreement with this order of creation, are the contents of all the numerous strata lying above those already mentioned; including the blue clay which we have seen disposed in many places almost at the surface . . . . . . In the next period it is stated, that the beasts of the earth, cattle, and every thing that creepeth upon the earth, were made. (Gen. i. 24.) The agreement of the situations in which the remains of land animals are found with this stated order of creation, is exceedingly exact; since it is only at the surface, or in some superficial stratum, or in comparatively some lately formed deposition, that any of the remains of these animals are to be found. The creation of man was the work of the last period. (Gen. i. 26.) And in agreement with his having been created after all the other inhabitants of the earth, is the fact that not a single decided fossil relic of man has been discovered." Thus, "a pleasing, and perhaps unexpected accordance, appears between the order in which, according to the Scriptural account, creation was accomplished, and the order in which the fossil remains of creation are found deposited in the superficial layers of the earth. That so close an agreement should be found of the order of creation, as stated in Scripture, with the actual appearance of the depth of stratification which has been examined in modern times, must satisfy or surprise every one—Moses could not have learned this accordance from the Egyptians [1]."

[1] Organic Remains, &c. Vol. iii. p. 449, et seq.

Cuvier has remarked that the order which the Mosaic cosmogony assigns to the different epochs of creation, is precisely the same as that which has been deduced from geological considerations. "According to Genesis, after the earth and the heavens had been formed and animated by light, the aquatic animals were created, then plants, then terrestrial animals, and last of all man. Now this is precisely what geology teaches us. In the deposits which have been first consolidated, and which consequently are the deepest seated, there occur no organic remains; the earth, at that period, was therefore without inhabitants. In proportion as we approach the upper strata, we find appearing at first shells and remains of fishes, then remains of large reptiles, then bones of quadrupeds. As to the bones of the human race, they are met with only in alluvial deposits, in caves and in the fissures of rocks; which shows that man made his appearance upon the earth after all the other classes of animals."

The following opinion on this subject is given by Prof. NECKER DE SAUSSURE, in his Discourse on the History and Progress of Geology:—"The order of succession of organised beings at the surface of the globe," the professor says, "which in Sacred History corresponds with the order of their creation, and the comparative recentness of the human race, are indications of a supernatural light thrown in the midst of the profound obscurity and absolute ignorance of the people of primeval times[1]."

Baron de FÉRUSSAC, the learned editor of the Bulle-

[1] See Edinb. Phil. Journ. Vol. xii. p. 322.

tin des Sciences, after admitting the general analogy subsisting between the order of creation, as manifested by geology, and as stated by the sacred historian, expresses himself as follows respecting the productions of the fifth "day" or period:—"With regard to the fifth day, the order of creation therein enumerated is in perfect accordance with that in which the fossil remains of the various races of animals occur. Animal life was first developed in the bosom of the seas; then in the air, reptiles followed, quadrupeds next, [in the sixth day] and lastly man [1]."

On this close correspondence subsisting between the order of fossil strata and the Mosaic history of the creation, the following judicious observation is made by Mr. Faber: "This remarkable coincidence affords, so far as I can judge, a physical demonstration, that the order of the six days and the order of fossil stratification stand immediately connected together in the way of cause and effect. For, unless this be admitted, we must ascribe, not very philosophically, the uniform coincidence in question to mere unmeaning chance [2]."

A rapid view has thus been given of the fundamental propositions advanced in De Luc's theory of the earth, in their connection with the sacred writings. The assemblage of undoubted facts, he observes, supplied by the attentive study of natural objects, is altogether independent of a pre-existing history, as

[1] See M. de Férussac's review of the "Défense du Christianisme," by M. de FRAYSSINOUS, inserted in the Edinb. New Phil. Journal, Vol. v. p. 89. 1828.

[2] Treatise of the Three Dispensations, Vol. i. p. 157.

well of what was the order of things in their creation, as of the principal events that have happened at the earth's surface since mankind has existed. The Mosaic narrative is of so peculiar a nature, that the circumstances which it relates could not have been discovered previously to our times, in which the scientific observations of the phenomena have furnished adequate means of comparison. In respect to traditional knowledge, mankind must have been ignorant of what had happened in the universe and upon the globe, before their own existence; and geology makes it evident that they existed only after all the classes of animals, of which they could not consequently know the history. Yet the recital of Moses we find is impressed with the seal of truth. Now if, before geology was prosecuted as a science, the sacred historian recorded truths which mankind could not of themselves discover by any other means, he could do so only by immediate Divine inspiration [1].

[1] Correspondance entre le Dr. Teller et J. A. de Luc, pp. 38, 39. The following sound remarks, connected with the above train of argument, are made by the author in his Lettres sur l'Histoire de la Terre, &c. Vol. v. Part ii. p. 637. "Stating to mankind the great fact of the creation, Moses enters only into such details as were necessary to mark the real *succession* of the distinct parts of the sensible universe: a succession which, in as far as concerns the earth in particular, is actually ascertained from the inspection of the phenomena, with regard to every natural object the traces of which are not as yet obliterated. We at the same time perceive why that order of the process of creation, is that which is most fully detailed, namely, because it was the only part which had a direct interest for man; and in order that by gratifying his thirst after knowledge, he might arrive so far by the study of the phenomena, and thus come to understand, that what revelation had taught him beyond, was indu-

"It would indeed, have been impossible for the human mind to have embraced the mysteries of creation; or to have followed the history of the moving atoms, from their chaotic disorder into their arrangement in the visible universe; to have seen dead matter assuming the form of life and animation, and light and power arising out of death and sleep. The ideas therefore transmitted to, or presented by Moses, respecting the origin of the world and of man ...... though general and simple truths, were *Divine truths*[1]."

The geological propositions themselves will be found developed and established in the following Letters; and their general truth has been admitted by the most distinguished naturalists. It was with a confident, yet modest anticipation of such an acknowledgment, that in his preface to his earliest geological work, De Luc hesitated not to express his belief that although some subordinate parts of that theory should prove to be defective, still the foundations of it would remain unshaken[2].

bitably true." See likewise Letter VI. of the present work, § 52. For a striking and unexpected character of truth in the Book of Genesis, as evidenced by the progress of natural knowledge, the reader is referred to Letter IV. §§ 19, 20.

[1] "Consolations in Travel; or the last days of a Philosopher," by Sir H. Davy, late president of the Royal Society.

[2] Some errors into which the author has fallen, but which are not considerable enough to affect the fundamental points of his theory, will be noticed as they occur in the work, and rectified from recent and more accurate observations.

SECTION VII.

General Inferences. A true Theory in Geology not undiscoverable.

THAT a true theory of the earth is not discoverable, will now scarcely be asserted;—a theory, such as shall not only have for its aim to "discover the laws that regulate the changes on the surface, or in the interior of the globe[1]," (to which object Prof. Playfair would limit every investigation in the history of the earth) but such as at the same time shall not set aside enquiries respecting a primitive constitution of our planet, whence those changes might follow; nor exclude the light resulting from certain well determined origins. While no one was more aware than De Luc of "the folly of attempting to explain the first origin of things," and of the necessity of trusting for a knowledge of it to the only source from which man can derive such knowledge[2]; yet he was well assured

[1] "Illustrations of the Huttonian Theory."

[2] "Can man apply the idea of *origin* to any thing besides what his observation shows him to exist? And can he form any idea with respect to the mode of first existence? By no means; and for that reason, God has revealed to him as a fact, that the heavens and the earth began to exist by his will········Man is a finite being, and every thing that is infinite, is above his understanding. God, therefore, in his supreme wisdom, revealed to him those things only which he could understand as facts, *his* own existence, and that the universe proceeded from *Him*." This passage is extracted from De Luc's review of Dr. Hutton's Theory of the Earth. See the *British Critic*, for October, 1796.

that by "tracing with the necessary attention the characters of geological monuments, a succession is clearly discernible, by means of which it is possible to go back to some epoch, at which none of them did as yet exist; and to determine what was then the state of things upon our globe, and what are the causes from which its actual state has proceeded[1]." This was the principal object which Bacon had in view in his physical researches, viz. the being enabled to ascend up to the origin of the phenomena of the universe; inasmuch as the different *successions* which he perceived there, did not allow him to imagine that it had always existed[2].

The author thus drew a broad line of distinction between what is discoverable by an attentive study of the phenomena, and what manifestly exceeds the reach of human capacity. He observes, after pursuing a train of reasoning, characterised at once by novelty and power, (in his Précis de la Philosophie de Bacon, Vol. ii. p. 112. et seq.) that there are different *origins* to which it is evident a cause must be assigned not belonging to the universe—a cause altogether distinct from matter, and to which we must have recourse for

[1] Elementary Treatise of Geology, § 16. "If it be necessary to divide into distinct groupes the different kinds of strata presented at the earth's surface, and to ascertain their superposition, it must still be remembered that this is not the whole of geology. Such divisions are too often arbitrary: the knowledge of the superposition of the formations is moreover one of the means only which we possess for arriving at the much more important knowledge of the origin of those formations; of the nature and structure of the earth we inhabit, and of its history." Bibl. Univ. Tom. xli. p. 82.

[2] Précis de la Philosophie de Bacon, Vol. ii. p. 101.

the formation of the universe constituted as we find it. These origins are as follows:—" 1. The formation of great bodies in space, already composed of the elements necessary to the production of all that we observe in them. 2. The production of light, which alone contains different particular origins; and first that of liquidity in the great bodies, which has given birth to all the chymical operations of which their elements were susceptible; such as the emission of light by the bodies called luminous,—the formation upon our globe of mineral strata, and their catastrophes,—that of the atmosphere, with its successive modifications; effects absolutely necessary, I do not say to the *production*, of which we can know nothing, but to the preservation of the organised beings produced at certain epochs. 3. The origin of the projectile motion of the planets, and by legitimate induction, of all the great bodies. 4. That of the rotatory motion in such of those bodies in which we perceive it, and in all those which, probably, are likewise subjected to it. 5. Lastly, as it appears from the whole preceding considerations, that gravity certainly does not belong to matter as a *property*, I do not hesitate to rank, with M. Le Sage, in the number of the great origins in the universe, the motion impressed upon the specific corpuscules,—upon those agents, immediate or mediate, of all the movements simply physical which take place in the universe, with the exception of the projectile motion of the great bodies: or more generally, (in order here to avoid the introduction of a particular system,) upon the material agent, whatsoever it may be, of gravity, of cohesion, of the affinities, and of

expansibility. These several origins have certainly *a cause which does not belong to the universe* [1]."

Theories which have a rational foundation are justly considered by Prof. Playfair as being frequently "approximations to the truth"..... "steps in the advancement of knowledge"..... and he well observes, that the "rise and fall of theories in times past, does not argue that the same will happen in the time that is to come." "Among the prejudices," he observes, "which a new theory of the earth has to overcome, is an opinion held, or affected to be held, by many, that geological science is not yet ripe for such elevated speculations. They would, therefore, get rid of these speculations, by *moving the previous question*, and declaring that at present we ought to have no theory at all. We are not yet, they allege, sufficiently acquainted with the phenomena of geology; the subject is so various and extensive, that our knowledge of it must, for a long time, perhaps for ever, remain extremely imperfect."

Respecting, however, such scepticism in geology, Prof. Playfair makes, in the same passage, the following acute and philosophical observation:—"Where the phenomena are few and simple, there may be several different theories that will explain them in a manner equally satisfactory; and in such cases, the true and the false hypotheses are not easily distinguished from one another. When, on the other hand, the phenomena are greatly varied, the probability is,

[1] In a passage which precedes the above observations, the atheistical hypothesis, that motion is essential to matter, is subverted, upon physical principles, by a new and incontrovertible argument. See also Letter III. § 3. et seq.

that among them some of those *instantiæ crucis* will be found, that exclude every hypothesis but one, and reduce the explanation given to the highest degree of certainty. Hence the number, the variety, and even the complication of facts, contribute ultimately to separate truth from falsehood; and the same causes, which, in any case, render the first attempts towards a theory difficult, make the final success of such attempts just so much the more probable [1]."

We find a similar sentiment expressed by Bacon two hundred years earlier:—"Let no man," says that great philosopher, "be alarmed at the *multitude of the*

[1] This passage is quoted and commented upon in De Luc's "Elementary Treatise." "We are by no means of opinion," observes the writer of a valuable article on G. *Brocchi's* Conchiologia Fossile subapennina (Edinb. Rev. LI. p. 157.) that the geologist ought to confine himself to a bare narration of facts, and that he ought to abstain from all theoretical speculations upon them: this is a doctrine that is, we think, rather too much insisted on in the present day; for although the geologist cannot be too much on his guard against the influence of theory in his observations of nature, and ought as carefully to abstain from the use of theoretical terms in his descriptions, it must be admitted that theory is the ultimate object of all geological researches."

The Rev. W. Conybeare, in one of the "Letters" noticed in Sect. IV. of this Introduction, after remarking that "theory will always become necessary at a certain period in the progress of every science," for the purpose of generalizing and consolidating past observations, and directing the course of future researches, asserts it as his belief, that "the station which geology has now assumed" would "require and repay this combination of theory and observation."

Although many years must necessarily elapse before the field of geology shall have been thoroughly explored, still it can no longer be doubted that certain essential points in the science are established upon an immoveable foundation.

objects presented to his attention ; for it is this, on the contrary, which ought rather to awaken hope." And no one adhered more scrupulously than our author, to the advice with which this remark is accompanied, that when interrogated respecting the objects of nature, philosophers should enable themselves to solve every *question* by *facts*, as this would lead in a short time to the discovery of causes, and the foundations of all sciences [1].

Approximations to a true Theory by De Luc.

As an evidence how carefully De Luc abstained from all hazarded conjectures and all arbitrary conclusions in his investigations of geological science, of all sciences the most comprehensive, since it embraces the most important branches of human knowledge,—how studiously he sought after, and abided by facts alone, reference is here made to the EXPOSITION OF GEOLOGICAL FACTS prefixed to the first vol. of the Geological Travels, 1810. The points to be established by each class of phenomena are there arranged under certain heads; and the author contends, that provided the facts generalized under each head be certified by the whole assemblage of the descriptions which respectively concern them, all the conclusions thence deduced are incontrovertible. At the end of the third

[1] "Interim particularium multitudinem nemo reformidet, quin potiùs hoc ipsum ad spem revocet······Apud nos verò si esset præstò quispiam qui de facto naturæ ad interrogata responderet, paucorum annorum esset inventio causarum et scientiarum omnium." Nov. Org. Aphor. cxii. vol. iv. p. 297. See Elementary Treatise, § 18.

vol. is a copious table of the Geological Facts described in the three volumes of the Travels, arranged under the heads which they respectively tend to illustrate; with references to the volumes and sections. Likewise, at the end of the second vol. of the Travels in France, is annexed a similar table of the Facts described in them, arranged as belonging to the two periods of the History of the Earth, which are distinguished in the *Conclusion;* with references to the volumes and sections.

By thus adducing an ample collection of particular facts, De Luc has endeavoured to remove that impediment to the advancement of geological science, which he believed to exist in the usual mode of exhibiting such phenomena under general points of view only; from which neglect, indeed, the author at the commencement of his geological career found all the prevailing systems premature and defective. In order therefore to collect a sufficient number of facts to give ground for solid conclusions, he was induced to undertake a course of regular observations. With that object constantly in view he began his excursions among the mountains in the neighbourhood of Geneva, in the year 1754, while he engaged in experiments on the measurement of heights by the barometer, and on the heat of boiling water at different levels. Throughout the whole course of his subsequent Travels, he expended much time and great labour both in studying terrestrial phenomena at various elevations and in different parts of our continent very remote from each other; and in following the progress of physical causes as well general as particular.

"It is not necessary to have made great advances

in the history of the earth," he observes, "in order to discover that our globe has undergone a variety of changes; but what are their *nature* and *causes*? These questions afforded subjects of great interest both to my brother[1] and myself, when we first began our excursions among the mountains; and we soon found that all which had been published respecting them down to that period, were mere illusions, produced by the impatience of the human mind[2]." It may here be

[1] The author's Lettres sur l'Histoire de la Terre, &c. and his Recherches sur les Modifications de l'Atmosphère are enriched with many valuable scientific observations by his brother, Mr. G. A. de Luc. "I am acquainted with no naturalist," he says, "who has studied volcanic phenomena with such attention as my brother, who for that purpose visited Mount Etna, Vesuvius, and the Lipari islands, and had thus occasion to witness several eruptions and explosions of masses of lavas and ashes through the mouths of the craters." (Abrégé de Géologie, p. 45.) Mr. G. A. de Luc likewise published several Memoirs in the Journ. de Physique from 1789—1804; in the Bibliothèque Britannique; and in the Mercure de France.

[2] Introd. à la Physique terrestre, &c. Vol. ii. § 859.

In a work, however, published at Florence, in 1669, by STENO, a Danish physician, entitled, "Prodromus de solido intra solidum contento," the author, after having shown in various ways that the shells met with in our stony strata, must formerly have existed in the sea, can find no other mode of explaining the phenomenon than by supposing, agreeably to the theory set forth in the preceding pages, that those strata were successively produced by the precipitation of particles separated from a liquid which once covered the whole globe, and contained all the ingredients of our strata, which were separated by chymical operations. But he assigned no cause for the successive change of the strata, which change, considered in itself, constitutes one of the greatest geological phenomena, and which it was reserved for De Luc to explain. De Luc was unacquainted with the work in question until after the completion of his

remarked, that the great distinction to which as a naturalist the author has attained, is mainly to be ascribed to that happy union of genius and perseverance, of which he was so eminent an example, and which is the attribute of all those who successfully open new paths in the field of science.

The close connection which subsists between each of the parts of the present theory—supported as they are by a series of facts, comprising the whole physical history of the earth—together with the frequent *unexpected* verification of it by the phenomena, impresses upon the whole system the character of truth; and cannot fail powerfully to arrest the attention of the diligent and unprejudiced enquirer. To direct the student to the several works containing the detail of facts and physical principles upon which the theory is grounded, and which have been enumerated in the beginning of the Introduction, (pp. 2, 3.) is one of the objects which the Editor has had in view; while the summary here presented may enable him to follow with greater facility and interest the developments of the theory contained in the following Letters. It will then be found that the whole of the history of the earth is considered by De Luc as connected with

geological labours, which corroborated several of the views of its author. "No trace of geology, as a science," says our author, "is found before the time of Steno, but we behold in him a striking instance of what a man of true genius can achieve for the advancement of the particular branch of science to which he devotes himself. Had this work been better known it ought to have prevented the publication of various theories which have since appeared." For an interesting account of the Prodromus &c. see Abrégé de Géologie, p. 2. et seq. Paris, 1816.

the four principal propositions which the observations assembled in his Travels will all concur to prove:—

1. The catastrophes, of which evident marks are impressed on the mass of our continents, by the valleys among mountains, the cavities of lakes, and the disturbed situation of the strata in the irregular skirts of these continents, took place at different periods, while the greater part of our present land constituted the bed of the sea.

2. The birth of these continents was produced by the subsidence of others, over which the sea flowed, abandoning its ancient bed.

3. Since that great revolution on our globe, the level of the sea has never changed.

4. From the known operations of causes of every class upon these continents since their birth, it is certain that they cannot have existed a great many ages.

A peculiar circumstance to which he himself adverts in his "Précis de la Philosophie de Bacon," characterizes the theory of De Luc, in contradistinction to all others. Those, he says, who have studied the theory will have remarked that one hypothesis only is assumed, and which was stated to be so at the outset; viz. that the globe was at first composed of disunited particles, liable to subside by the infiltration of water. The advancement, indeed, of some fundamental hypothesis of this kind, upon the framing of a geological system, is the condition which has been required by all those philosophers who have ascertained that the present state of the earth is the ultimate result of a succession of past states, commencing from a certain epoch. Thus, amongst other eminent naturalists, Pini, Dolomieu, and De Saussure,

have each required that those who undertake to determine the history of those past states, should previously ascertain, by physical characters, the state in which the earth must be supposed to have been at the commencement of the operations which have taken place; proceeding afterwards to indicate the physical causes which had effected a change in that state. When the hypothesis above adverted to is admitted, all the rest of the theory follows as consisting only of inferences, successively immediate, from well determined facts, and from principles generally acknowledged in chymistry and mechanics. If, then, all the principal geological features are thus explained, without any admixture of arbitrary conclusions,—and if, moreover, no fact or acknowledged principle can legitimately be opposed to such conclusions, the fundamental hypothesis is thereby satisfactorily proved. This remark, however, applies to *causes* only; for the events themselves, such as they have been described, do not depend upon them [1].

[1] Précis de la Philosophie de Bacon, Vol. ii. pp. 330, 331. "All the great geological phenomena, which lead us back to the past, such as the successive formation of the strata, their partial subsidences at different periods, the two principal subsidences embracing a great portion of the globe,—events attested by very intelligible monuments,—had their causes in the primitive constitution of the earth. Those causes are exhausted, and their effects have ceased since the last great revolution which gave birth to our continents. From that epoch there has been no further formation of fresh mineral strata, the liquid of the new sea, having been divested of the substances which could produce them; no further fractures of the strata have taken place, through which new quantities of the liquid were introduced into the interior of the globe, and there renewed the same chymical operations; volcanos constitute the only

Close connection of all the Parts of De Luc's Theory.

The solution of the phenomenon of caverns given by the author may be here adduced in proof of the close bearing of the several parts of his system upon each other. The existence of such cavities in the interior of the globe, he observes, is an established point in geology. Whether the theory of elevation, or that of subsidence, be the true one; whether the highest parts of the earth have been raised, or the lowest have been depressed, it is only by admitting the existence of caverns that we can explain the operations which constitute a part of either system[1]. In the theory of subsidence, adopted by De Luc in his first work, their formation was a necessary result of successive infiltrations of the liquid into interior parts of the earth, and the consequent subsidence of the pulvicules towards the centre of the globe. At each catastrophe of the strata, expansible fluids with which the caverns were filled impregnated the liquid

remaining symptoms of any violent subterranean operation, and neither the bed, nor the level of the sea have sensibly changed." Ibid. pp. 328, 329.

[1] "In the theory of elevation, our lands must be considered as forming the vault of caverns produced below them; and those caverns must not only have all the depth of the elevated mass, but likewise the whole extent of the present continents. Now, should we even grant that expansible fluids had been capable of elevating the land, how could they have been retained by a vault of such an extent, fractured and dislocated in innumerable places? They must necessarily have escaped, and the vault remaining without support, would have fallen back in fragments on the bottom from which it had been detached." *Abrégé de Géologie*, pp. 23, 24.

with new ingredients, thus occasioning a change in the nature of the precipitations—a change proved by the superposition of strata successively different. During these precipitations the expansible fluids themselves changed their nature, and gradually formed our atmosphere. De Luc likewise shows, from the theory of subsidence, that while the catastrophes which the strata underwent at different periods, demonstrate that caverns must have been successively formed beneath them, the important phenomenon that has given birth to geology, is explained, viz. the disappearance, at the exterior, of a great portion of the liquid which formerly covered the whole globe, at a level exceeding our highest mountains [1]. At the termination of the catastrophes, those cavities were nearly filled up by the masses of strata, which, as they sank, descended to the bottom. The stability of our continents was thus effected, and such vacant spaces alone remained as occasion the present phenomena of volcanic eruptions and earthquakes [2]. For the caverns were not receptacles for

[1] Letter V. § 6.

[2] Letter IV. § 7. Of these phenomena a very satisfactory solution, in immediate connection with the leading features of the system, will be found in Letter IV. of this collection. See also Journ. de Physique, tom. xxxviii. p. 274; tom. xl. p. 451; xli. (part ii.) p. 227; and xlii. p. 235, (1793.) "There is," says M. de la Métherie, "a very considerable number of volcanos which are at this day extinct. Large caverns must necessarily exist beneath the spots where they were once in activity." Journ. de Physique. The great earthquake at Lisbon, in the year 1755, which was felt at the same time in several countries of Europe, proves the existence, in that part of our hemisphere, of very deep and extensive caverns. Journ. de Physique, tom. xli. (part ii.) p. 329.

the liquid, but served as avenues for its further infiltration into the porous mass of the globe [1].

To discover any one particular cause of the disappearance of the liquid at the exterior, remarks our author in his xxxth Letter to M. de la Métherie, is of no avail towards serving as a foundation of a theory of the earth; all other geological monuments connect themselves with this fact, and require that its cause should explain them also. Accordingly the discovery of such a cause can result only from a long study, of all the principal geological phenomena, and all the laws of terrestrial physics. But the time, the labours, and the perseverance required by this study, are amply compensated by the light which the different phenomena reflect one upon another,—a real light which alone can lead to a geological system of which the bases are found in nature [2].

SECTION VIII.

Moral importance of Geology.

At the conclusion of the sixth Letter occurs a brief recapitulation of the motives that induced De Luc to apply himself to geological researches. It is evident that no subject is calculated to awaken a more general interest than that which connects itself with the history of our planet, since the consideration of physical events which relate to the globe inhabited by man, necessarily involves the consideration of the history of man himself, and may serve to confirm what

[1] Journ. de Physique, tom. xlii. p. 235, (1793.)
[2] Journ. de Physique, ibid. p. 234.

a venerable tradition has from the earliest times established among mankind, and what it most concerned them to know, viz. their origin, their duties, and their destination. Hence the study of the monuments of the revolutions which the earth has undergone, together with their causes, assumes a great moral importance [1].

Investigations into the physical history of the globe having naturally called back men's attention to that history, as it is contained in Genesis, and also to that of the human race, with which it is connected, it was soon inferred, that, if geology were contrary to Genesis, the latter must be fabulous. "This is a consideration," says the author, "which I offer to those, whose profession it is to teach and defend revealed religion. The weapons by which it has been attacked have been changed, and our modes of defence must be adapted to the arms of its assailants. They now attack it through geology; which therefore becomes a science as essential to theologians, as the study of learned languages, or of those ancient arguments, which are already much neglected in the present times, and which must henceforth derive their chief support from the very science, through the medium of which, under the pretence of an appeal to facts, it is attempted to set them aside [2]."

Although the first geological systems contrary to revelation have fallen to the ground, in consequence of the increase of knowledge, the premature attempts of those who have written in its defence, have likewise produced various chimerical theories. "The adver-

[1] Letter VI. § 51. [2] Elementary Treatise, § 6.

saries of Genesis," remarks De Luc, "by overthrowing those groundless systems, imagined that they triumphed over Genesis itself. While geology, therefore, was in its infancy, philosophers should have contented themselves with pointing out the errors of the anti-mosaical systems, for which the state of the physical sciences was sufficiently advanced to have readily furnished them with the means: and they should not have hazarded theories, before they had taken every requisite precaution to fix them upon an immoveable foundation [1]."

[1] Ibid. § 9. Mr. Lyell asserts that De Luc "imputes the failure of former geological systems to their having been anti-mosaical," p. 68. It is obvious that in the passage to which he adverts (Elementary Treatise, § 8.) Mr. L. has misapprehended the meaning of our author, who simply states that the geological systems which had been published contrary to Genesis, had "*fallen in consequence of the increase of knowledge*," and reproves the levity and imprudence of such attacks on that, which a sublime tradition had established among men. De Luc more particularly alludes to the writings of certain foreign naturalists, such as the German work entitled, Die Geognosie nach chemischen Grundsatzen, by Dr. CHARLES SCHMIEDER, member of the Society of Halle. The general principles and cosmological system of that author are investigated and combated by De Luc in his Abrégé de Principes et de Faits concernans la Cosmologie et la Géologie. (1803.) Another publication, by Prof. POTT, of Helmstedt, called forth the animadversions of our author. "When the professor," he observes, "wrote a work entitled 'Moses.... *no Geologist*,' he uttered, without perceiving it, a great truth; for if Moses unfolded, before geology existed as a science, truths which men were unable of themselves to discover by any other means, he could do so only by divine inspiration." Mr. Lyell will thus find, contrary to the opinion he expresses, that there *are* writers who have openly or covertly, "been guilty of endeavouring by arguments drawn from physics, to invalidate scriptural truths." p. 68.—"Voltaire, d'Alembert, Diderot, &c." observes De Luc, in a letter written

The venerable author further states that he has devoted fifty years of his life to these investigations[1]; and he makes the pious and affecting acknowledgment, that in consequence of the conviction which they produced in him of the truth of revelation, he "found the reward of his labours in an inward satisfaction, which the vicissitudes of his life, although not inconsiderable, have never been able to destroy."

Anxious, from the deep impression which he ever entertained of the importance of the subject, to excite a more general desire after geological enquiries, the author, in his preface to his Travels in the north of Europe, makes, with that view, some valuable observations, the substance of which will furnish an appropriate conclusion to the present introductory remarks :—

"The history of our globe, like every other which relates to past time, can be traced back only by monuments. It is thus that the histories of nations have been compiled; but of those the most ancient

to Mr. EMERY, the editor of the French edition of the present work, "addressing the imagination and the feelings, were especially calculated to mislead the unthinking; but minds capable of any reflection, and of maintaining principles of their own, would have escaped their influence had not Buffon, Maillet, le Cat, and other natural philosophers of their class, appeared to assure the world that every thing in nature was opposed to the Mosaic history, the base on which revelation is founded." Mr. BABBAGE, Lucasian Professor of Mathematics, in the University of Cambridge, adverts in like manner to the "geological speculations which have been adduced as inconsistent with the Mosaic history." Reflections on the Decline of Science in England, p. 137.

[1] Letter VI. § 51. With a persevering activity seldom witnessed at such an advanced age, De Luc carried on his geological researches for upwards of fifteen years after the date of that letter.

monuments have been successively effaced or disfigured by a thousand various events and interests; and, for the most part, nothing remains in that respect but traditions, obscure, imperfect, and often fabulous: hence have arisen so many contradictions in the early annals of the same nations; and from these has originated historic doubt. The case is not the same with the history of the earth; the monuments of this are of too great magnitude to have been essentially changed by mankind, and the surface of the globe is covered with them: they remain, and may still lead to truth........ The question to be decided is no less than this: whether geological monuments authorize us to discard, as so many authors have done, either explicitly or implicitly, the only written history of the earth, and of mankind, which now exists; a history more ancient than any other authentic writing, the origin of all religions, and the first, the positive, the only foundation of our own. When the study of the earth shall have become more general, there will be much greater difficulty than at present, in circulating errors respecting the only basis of the repose and happiness of mankind [1]."

---

[1] The following observations of an eminent geologist of the continent, M. de Férussac, will be perused with satisfaction:—"If every thing around us did not testify that knowledge is at all times man's safest guide, geology, which after having in its infancy supplied arms against the sacred writings, serves at this day to uphold the Mosaic cosmogony—would furnish a memorable instance of that great truth······Where, in our times, shall we find the geologist, who, while admiring the great genius of Voltaire, could forbear smiling with pity at his elaborate attacks on the Book of Genesis?" Bulletin des Sciences Naturelles, tom. x. pp. 194, 195. (1827.)

Means of facilitating the Study of Geology, indicated by De Luc.

The editor is here desirous of directing the reader's attention to the following interesting remarks on the mode in which the study of geology may be most successfully conducted. They are introduced by De Luc in Vol. iii. of his Geol. Travels, p. 505. et seq. " When geological researches were first undertaken, which was not till a very late period, it appeared to be necessary, for the purpose of rightly understanding the events which had taken place on the earth, to seek for monuments of those events in very distant regions; in the chains of the highest mountains, on the courses of the largest rivers, and in the celebrated deltas formed at the mouths of the latter. Such great features of our continents ought undoubtedly to be studied, as belonging to one of the classes of monuments of the history of the earth; but when attention is wholly confined to these, as if all the knowledge necessary to geology could hence be acquired, the consequence is, not only that the number of those who can engage in this study by immediate observation must be very limited, but that those who do enter into it, being thus restricted to so small a portion of the facts, and of the connections subsisting between the different classes of phenomena, are inevitably divided among themselves with respect to the systems formed on the succession of effects, and on their causes: and that consequently, although, since the time these studies have begun to produce systems

on the *History of the Earth,* they have become of great importance to all mankind, yet the generality of men, who consider the subject as above their capacity, feel little interest in it; and if they take any part in such controversies, it is only by chance that they are guided.

"Such is the state of things which I have witnessed ever since I have myself been occupied with geological opinions; and I have also seen the effect produced in the world by these opinions; but, in studying the phenomena by which they ought to be determined, and which I have followed in all their various branches, from the highest mountains, down to countries of hills and plains; from the courses of large rivers, to those of brooks and rivulets; from the new lands added to the continents near the mouths of rivers, to those which have filled up bays, gulphs, and even the smallest creeks; lastly, from the highest cliffs, to the coasts which slope down insensibly to the sea; I have clearly found the *History of the Earth* to be traced in the same manner, only with characters differing in magnitude, in all parts of the surface and of the coasts of the continents; and thus to be really within the reach of every person who will attentively pursue the study of its monuments.

"On this account, I was induced, in the latest of my travels in countries of the most common character, to extend my notes to a greater number of objects, with all the details belonging to them, in order to give examples of the multiplicity of important phenomena which every man may observe around his own habitation, or in his accidental journeys; and these I have published the first, with a hope that they may excite

a taste for such studies, in themselves very amusing, and may thus every where increase the number of observers.

"It is almost indifferent what places of observation are chosen, for the purpose of at least forming a clear idea of studies of this kind; for in all countries interspersed with eminences and low spaces, the phenomena are the same as among mountains, only on a smaller scale; and with regard to the coasts, if attention be paid to the actions of natural causes on them, there are few of any extent, where examples of the real operations of the waters of the sea and land may not be found."—"Respecting geological observations, I can truly say from long experience, that no study can be more agreeable; for they beguile the weariness of journeys, and even of common walks, affording inexhaustible objects of attention and reflection." Geol. Travels, Vol. i. § 123.

LETTERS.

LETTER I.

On the phenomena characterizing the causes that have formerly operated upon the Terrestrial Globe; and particularly on those which fix the date of the origin of our Continents.

Windsor, September 1, 1792.

SIR,

I HAVE not forgotten, that when I had the pleasure of seeing you here, I engaged to furnish you in writing with the substance of our conversations on Geology; the performance of which promise want of time alone had caused me to defer.

You had read in the "Journal de Physique," the Letters I have addressed to the editor, M. DE LA METHERIE, on this subject, so closely connected with your studies: and as we soon found that we agreed on many points, it was very easy for us to embrace at once a variety of general views; by which means the different parts of my theory being brought more closely together, you more readily understood the connections and proofs. It then occurred to you that I ought to publish an abstract of this theory,

beginning, as was the case in our conversations, with the principal phenomena which determine the task of the geologist, as well as the point from which he ought to start, in order that he may remain within the bounds of known causes; limiting myself afterwards to extracts from those parts of my theory, the proofs of which are established in my works:—this, you observed, to naturalists acquainted with them, would be sufficient: in others it might serve to excite the desire of employing their attention on this important subject.

1. Geology is principally distinguished from Natural History, inasmuch as the latter is limited to the description and classification of the phenomena presented by our globe in the three kingdoms of nature, whilst it is the business of the former to connect those phenomena with their causes. Geology embraces, therefore, the whole extent of what we can acquire of natural knowledge, since our observations on the earth constitute the only true sources of all that knowledge. Astronomers, for example, could have taught us nothing concerning the causes which operate in nature, merely by determining, as Kepler did, the laws by which large bodies move through space: for if the cause of the fall of bodies on our globe had not conducted Newton to his theory of gravitation, we still should have been ignorant of the great laws of motion, the influence of which in nature is so general. Herschel, by his extraordinary skill in observation, has doubtless made great discoveries respecting the resemblances of other planets to the earth; no knowledge, however, could be drawn from thence of their past states, had not our studies on the

earth given rise to natural history, chymistry, staticks, and thereby revealed the great outlines of the history of our globe, which, by analogy, may be transferred to them. In vain, above all, would *light* have given us knowledge that an universe exists; this great assemblage of bodies would have been mute to us, as to its causes, had not the progress of observations and experiments upon our globe, discovered to us, in light itself, a substance capable of various combinations with other substances; and one without which all the other causes of the chymical affinities, those causes which, in the greatest part of the operations on these globes, have the most considerable influence, would be totally without effect. Such then is that geology, which is not merely nominal; it consists, as I have said, in the knowledge of the causes which have acted, and still act upon this earth; and thus it is that geology embraces all the knowledge we can gain of nature; as, on the other hand, there can be no real knowledge respecting nature,—in as far at least as depends upon mere human researches,—without an attentive study of all the terrestrial phenomena.

2. Why has the earth any mountains?—Such is the question from which I shall here set out, as, in my own private researches, which have never been intermitted, I set out from it forty years ago; and, before I can resolve this question, I shall have run through the whole field of natural knowledge, as far as I am master of it.

3. Why are there pyramids in Egypt?—This is a question which the antiquary puts to himself with some hope of finding the solution, because he sees

some data to set out from: now the whole course which he pursues respecting these edifices, marks out that of the geologist on the subject of our mountains, and of our continents, the bases that support them.

4. The entire mass of our continents is composed of strata, similar in this respect to the regular courses of stones in our buildings. A succession of strata indicates a succession of time for their formation; and the change from one species of stratum, to another species placed upon it, indicates a change of cause. Thus is the mass of our continents the product of successive operations, during which the producing causes have undergone successive changes.

5. We see, moreover, that many of these strata contain the remains of animals; and that in some successive strata these organized bodies are of different species. By this we judge that some considerable length of time was necessary for the formation of these strata, both on account of the succession of individuals of the same species of animals in some of them, and also on account of the change of species, in the same places where the former are buried.

6. By much the greater part of the organized bodies found in our strata consists of the remains of marine animals, and some of these are even found in all the classes of strata, which contain other kinds of bodies not belonging to the mineral kingdom; so that all these strata have been formed beneath the waters of the sea. Nevertheless, these other bodies are remains of terrestrial animals and vegetables. Whence proceeds this mixture of terrestrial and marine bodies? Here is another characteristic of the causes which have operated within this period.

7. It is in the mountains, those pyramids which rise upon our plains, that we see more clearly the succession of the strata; and there we discover that those which contain organized bodies, cover others which must have lain originally very deep, and which contain no vestige of these bodies. There was then a time when, according to all appearance, our globe did not contain any of the organic remains at present known; and it was in that time that these first strata were formed, which are chiefly observable towards the centre of the great chains of mountains, and to which our observation with respect to times past is limited. It was not till after the formation of these strata that any organized bodies existed on the land and in the sea; and their succession in our strata points out to us thus, a certain succession of periods in their own history, connected with that of the formation of these strata.

8. When we go back to times past, by the assistance of what may be discovered in the edifices raised by men, we employ ourselves chiefly in attending to their structure; as to the materials, we know their general origin;—that they have been taken from some of our strata. The case is not the same with the great edifice of our continents; for we should be very backward in our knowledge of geology, if we were unable to discover whence originate the materials of which those strata have been composed; and at this knowledge we cannot hope to arrive, without having first collected all the circumstances which relate to them. Of these, the following is one of great importance.

9. It is by considering the quantity of marine bodies

contained in our strata, beginning from the surface, and proceeding to a very great depth, and by observing the inferior substances, or which must have been so formerly, disposed also in strata, that we have concluded all these strata to have been formed within the sea. They ought not then to have any other inflexions than those which may be supposed to belong to a base on which deposits accumulate, preserving always their continuity and their parallelism. But all these strata are broken; great masses of them are evidently wanting in some places where formerly they must have been, and those which remain are visibly overthrown in a very considerable degree. It is, indeed, by this disorder only, that we are made acquainted with their various classes; for if they had not suffered fractures and displacements, as we could not then have seen directly any, except those by which the rest are covered; and as our means of penetrating the surface are very limited, we could have known them only to a very inconsiderable depth.

10. Here, then, appears the reason why, to the geologist, mountains become the first object of attention; it is because by means of these we learn what are the strata, even to a very great depth, which the loose soil of our plains envelopes. We see, in different parts of these eminences, the vertical sections of immense piles of strata, on the summit of which we find some which, in other very low situations, are again found at the surface of the soil. These sections are observable in all parts of the mountains; when viewing them on the outer side, we ask ourselves what is become of the remains of the great mass of strata, of which they have only been portions; and interiorly,

on looking at these sections on the opposite sides of large valleys, we ask ourselves, also, what is become of that portion of the strata which otherwise must have occupied the interval? In other places, the same strata which we had observed towards the upper part of certain vertical sections, form the external face of mountains, where they present themselves in a very inclined position. Their section is found on the summit of the mountain, where we see them resting one against the other; frequently they are thus divided into several ranges of eminences, the breadth of which indicates the thickness of the strata thus overthrown. In this very singular arrangement, the strata of different kinds, which in other places are seen one upon another, are found in distinct ranges of eminences, formed of those different substances, succeeding each other, with the sections of the strata at their summit; these strata, before piled one upon another, having been overthrown, after having been fractured through their whole thickness; those which were the uppermost, having slipped down on the outside. In the great chains of mountains, the strata, which originally were the lowest, approach the nearest to the centre of the different ranks, and their sections form the highest summits. There we observe, on each side of the chain, strata which contain organized bodies, leaning in several ranks against other strata of various classes, which have no such contents. That class of the strata which should be the lowest, as having been formed the first, (that is, the granite) predominates in the central line of the chain, where it presents only vast ruins, in the different masses of which the strata are found in every degree of inclination, but princi-

pally in a situation almost vertical, exhibiting the most irregular fractures.

11. Thus instructed on the nature of the strata in the mountains, and returning then to the hills and to the plains, the geologist there remarks a disorder which had not before struck him; the features are there of less magnitude than in the mountains, they are more veiled by new strata, which are spread over the ruins of the former, but they are still of the same kind. The strata of all classes are there found broken, overturned, disordered; so that the monuments of the causes by which the materials composing the mass of our continents were produced, are every where intermingled with symptoms of the causes by which their first arrangement was destroyed. Our continents, in a word, have been built up stratum by stratum at the bottom of the sea; then reduced to ruins; and, to complete the grandeur of the phenomenon, these ruins now stand above the level of the sea.

12. Such is the chaos which the geologist is called upon to explain, in the midst of which he must proceed, as the antiquary would among the ruins of Palmyra. It is by availing himself of the knowledge he has of architecture, and of the variations which, at different periods, it has undergone, that the antiquary determines times, and assigns causes, in their reference to the monuments of human industry. The geologist, in like manner, must study the general means employed by nature in her operations, together with the circumstances which have produced changes in them, that he may be enabled to distinguish the causes denoting certain periods, in those monuments of the great succession of natural events which our

globe presents to his observation. Here, moreover, it is necessary that he should have recourse to the general collection of facts carefully observed, and of laws certainly discovered in the study of nature; that is, to all that is most certain in natural history, and physical science.

13. Time was one of the indefinite agents to which geologists were used to assign the emersion of our continents; by means of that, they thought they could make up for the feebleness or the indeterminate nature of the operating causes, without, however, pointing out, in any case, a single determinate effect produced within a given space of time. The only means of reducing to order the chaos of geological monuments, was to seek some great epoch in their succession; and since the most striking of these phenomena, that which indeed gave birth to geology, is, that our continents, at present above the level of the sea, were unquestionably once beneath its waters, it was necessary at the first to examine, whether we could not discover some indication of the time which has elapsed, since it has ceased to cover them. This is the essential point which I have determined in my "Lettres sur l'Histoire de la Terre et de l'Homme." You, Sir, know that I have demonstrated, from phenomena of different classes, perfectly clear and definite, that our continents are of very little antiquity; which truth has also been acknowledged by two celebrated geologists, M. M. de Saussure and Dolomieu, whose observations, no less precise than numerous, have so much enriched the science of geology; and to whom we are also indebted for throwing great light on the other monuments of our

globe, and their causes. I might, therefore, here assume, as an acknowledged truth, that our continents are of a date of very small antiquity, which at one blow overturns all the systems of geology, in which slow causes, acting for a succession of innumerable ages, were employed to explain their formation; but, as some of the phenomena which demonstrate the error of these systems, serve at the same time as steps by which we can trace back the causes that are past, I shall select two out of this class, to which I shall devote the remainder of this Letter.

14. It is remarkable that the phenomena, of which I am about to speak, are the very same on which the greatest stress had been laid in assigning to our continents an immense antiquity, which circumstance will give me occasion to point out in what manner observations were formerly made, and on what foundations systems were constructed. The first of the phenomena, of which I shall speak, is that of the bones of southern animals, which are found buried in our countries. Here, in truth, if we must suppose that the animals, to which these bones belonged, lived on these very parts of our continents, such as they now are, it is hardly possible to assign any limit to the time that must have elapsed between that period and the present. For it is owing to a want of sufficient heat in our climates, that these animals cannot subsist in them; in proceeding, therefore, from the state of actual causes, among which we can discern nothing indicating a tendency to any change of heat in these climates, the time necessary to produce this change would be as indeterminately im-

mense, as is the distance of the fixed stars, for want of parallax. Consequently, as M. Bailly has already observed, when we consider that in Siberia has been found a carcase of a rhinoceros, which had still a part of its skin entire, with the hair upon it, this mode of contemplating the phenomenon becomes absurd; but it is because it has been badly described that this error has arisen, into which M. Buffon, among others, has fallen; to prove which, I will produce a precise example.

15. You have seen, Sir, in my possession, two teeth of a hippopotamus, part of the skull of an ox, fragments of the tusks of an elephant, and other bones of the same animal, found by Mr. Trimmer at Brentford, six miles from London. What an association of animals in an island of the northern sea! But let us consider in what situation these bones are found, not only in the spot we now speak of, but also in other places. They are in a stratum of sand, which extends, at different levels, throughout a great part of the island, in the south and in the east, and always upon strata of one certain species of bluish clay. These two classes of strata are broken, inclined, divided, like the strata of coal, and the other indurated strata. In various parts of the island, and particularly in the vicinity of that where the bones above mentioned were discovered, this stratum of sand abounds with marine bodies; the stratum of clay below it always contains them, and above this sand are various other strata, more particularly of gravel: the bones in question were found under these strata, at the depth of from 15 to 18 feet. In digging for the clay, which is used in making tiles and common pottery,

similar specimens of bones have been found in various parts of the island.

16. This particular description includes the circumstances common to all the osseous remains discovered in the soil of our lands. I do not here speak of the bones which are found in caverns, covered with stalactite; that is a different phenomenon, which I have explained in my fourteenth Letter to the "Journal de Physique[1]:" I speak only of bones, such as I have now mentioned, which are discovered in loose strata, forming the surface of the soil. In all countries where these have been found (at least as far as I am informed, and my knowledge on this subject includes not only England, but Italy and Westphalia) the same loose strata which contain these remains of terrestrial animals, include also bones of fish, and marine shells, either in the same places, or in some other part of their extent[2].

17. We are not called upon in the first instance from those facts, to explain the presence of these southern animals in our countries, or to enquire how, and in what space of time, our climate has changed; for that would be to disregard the leading character of the phenomenon; but, we are called upon to enquire how, and since what time, the sea has quitted our continents; for it is only by ascertaining the cause of that revolution, that any clue could be obtained to the cause of the changes of climate.

[1] Tom. xxxviii. p. 271—288. 1791.

[2] In the author's Lettres sur l'Histoire de la Terre, &c. Vol. v. p. 333—340. he makes mention of some casts of bivalves which he found in a sand intermixed with concretions, near Dellden, in Over Issel, together with sharks' teeth, and the vertebræ of a whale.—Ed.

I speak of a change of this latter kind, because it must be indispensably admitted, if it be true that only a very inconsiderable time has elapsed since the elephant and the rhinoceros lived in these parts of the globe, where we find the carcases of their species: now these very carcases themselves, as well as the marine bodies which are found in the same strata, supply a striking proof of the small distance of that epoch. All these remains of animals are in loose strata, of different kinds, continually pervaded by the rain-waters, in which they are also perishing. The elephant's tusk, the fragments of which you saw in my possession, was nine feet in length; it was discovered whole, before any attempt was made to raise it; but, in doing that, it fell to pieces, having no more consistence than chalk. You know likewise that which is in the cabinet of M. André, at Hanover, taken out also in pieces from land traversed by the Weser; and the many other phenomena connected with the gradual decay of terrestrial and marine bodies, buried together in our loose superficial strata. Nevertheless, these bodies are not yet destroyed, and they are even found in a degree of preservation which absolutely excludes every idea of a very great antiquity; for, in Russia, they have found a great many tusks of elephants, so well preserved, that they were capable of being used as ivory. We thus perceive that the preservation of these carcases is more perfect in those regions, where, according to the hypothesis of Buffon, their decomposition ought to have commenced, namely in the north; and we find the cause of that more complete preservation in the length of the frosts, during which no waters can

pervade the soil. It was thus, for instance, that the carcase of the rhinoceros found in Siberia by M. PALLAS was preserved, which still retained a part of its skin with the hair. With regard to the marine bodies which, at the same period were deposited in the same strata, their preservation, in many spots, is such, that I have found in those loose strata upon hills, oysters which had the ligament of the hinge still soft, and other shells so well preserved, even in their colour, that they might have been supposed to be recently taken from the sea, though some were of a species no longer found but in the Indian seas [1].

18. We do not perceive in these loose strata any sign of violent agitation in the water that produced them: they have been formed, like all the other strata, by deposits made at the bottom of a tranquil liquid, and all the extraneous bodies which they contain were there enclosed, when, by other causes, they were broken and displaced. Thus we see then, without any doubt, that these remains of exotic animals, whether terrestrial or marine, were buried by the waters of the ocean, in the very places where they

[1] The shells which had retained their gloss and natural colour, were met with in Piedmont. Among others, the oyster, the hinge ligament of which became soft when immersed in water, was found by De Luc in Val Andoua, near Asti. He also met with a large chama filled with sand, in which were several small shells of the same kind, but containing no sand, probably because they had closed at the moment of this sudden catastrophe; and within these last he found the animal still in a soft state. In another sand-hill, some of the beds of which were hard and laminated, he found between the laminæ leaves of different trees, such as oak, alder, and willow, which had contracted only a brown tint; and they were intermixed with sea-shells.—ED.

are found; and that the retreat of the sea must have taken place at a time very little anterior to the periods which we trace back by the monuments of human art. For these monuments of past natural causes would no longer subsist, if our continents were of extreme antiquity. It cannot, then, be doubted that the sea covered our present countries when the elephant and rhinoceros occupied portions of land, doubtless islands[1]; and that, since that period, no great number of ages has elapsed; all which is perfectly independent of any explanation of the manner in which these things happened, being only an immediate deduction from the facts.

19. It is by adding observation to observation, and keeping to their immediate consequences, not by raising one hypothesis upon another in endless succession, that men acquire knowledge. Before our hills and plains had been studied carefully, before the quantity of marine bodies they contain, the manner in which these are formed, their degree of preservation, had been attentively considered; before the characteristic marks had thus been ascertained of a previous formation of these beds upon continuous bases, and of their subsequent fractures and dislocations, several geologists attributed our superficial strata to rain-waters, as having ravaged the surface of our continents for a succession of innumerable ages.

[1] It has been observed in the introduction, that islands alone seem insufficient to account for the universality of the phenomenon of the fossil bones, and that the quadrupeds must have inhabited a vast continent which formerly existed in these regions of the globe. See Introduction, Sect. II. (note) "Although interchanges of land," &c.—Ed.

It may be perceived already, that this hypothesis is totally contradicted, by the immense quantity of marine bodies contained in these strata. But let us pursue the investigation.

20. Agreeably to such an hypothesis, there should have been eminences from which these quantities of sand, gravel, and other loose materials might have proceeded; but they cover vast regions, where no trace of eminences exists. Here then began the apparent resource of all these systems; it was supposed, that by length of time these eminences had been levelled, and the whole of their fragments decomposed, and converted into sand. To support this opinion, examples were brought of great excavations observed in mountains, which were attributed to running waters, it being supposed that their fragments found in the plains have been carried there by those waters, and gradually reduced to sand. Then, indeed, it was impossible to be sparing of time; but those geologists thought they might bestow it without bounds, as the past is inexhaustible: let us, however, see whether it be allowable to substitute time for causes; and in the first place, let us examine whether the materials which we perceive thus missing in the mountains, have really been spread over the plains.

21. If it be the rain-waters which have hollowed out the valleys between the mountains, and left those ruins which we observe towards their summits; and if the same waters have carried off, and transported to a distance, that immense quantity of materials, the removal of which had formed the valleys; they ought, in their course, to have filled up every cavity, and thus to have levelled all the land within their range. Why

then do those lakes exist which are found at the outlets of many valleys belonging to the great chains of mountains? Running waters may indeed form channels for themselves, and in time widen them; but they cannot scoop out basins; for their mechanical action ceases the moment that their course is slackened, by their spreading over a wider space; and where they find a free passage, they flow again. The streams, then, did not excavate the basins of the lakes; they found them originally in their course; they, in the first instance, filled them with water, and there also they must of necessity have deposited whatever in their rapid passage they had borne away from the interior of the mountains. But these basins found in the course of so many rivers, and the dimensions of which, compared with the vast excavations observed in the interior parts of the mountains, may be considered as extremely small, are not yet filled up. Here then is a peremptory proof, that neither any of the fragments of the stony strata with which the plains and small hills are sprinkled, even to a great distance from the mountains, nor any part of the sands, which are formed over them to a considerable depth, have been carried off from the mountains[1];

[1] In a note to the editor on this passage, Mr. J. A. De Luc remarks, that although the rain waters have not brought down the fragments of the stony strata, they have nevertheless been carried off from the interior of the mountains, but through the intervention of a much more powerful cause. He has particularly in view the plains of Switzerland, between the Alps and the Jura, which are covered with the debris of the Alps, notwithstanding "the deep and tortuous channels" through which, if we suppose that circumstances were then the same as they are at the present day, they must necessarily have been propelled. M. Leopold Von Buch, in his Memoir

since nothing could pass beyond the lakes till they were first filled up and levelled. And, on the other

on the dispersion of the great Alpine stones, observes, that the phenomenon of the Alpine blocks is common to the valleys of the two sides of the Alps, and takes occasion to adduce several instances of primary blocks found at the outlets of the valleys of the lake of Como, of the lake of Lugano, that of Lecco which forms the eastern branch of the lake of Como, that of Olginate, that of Iseo which terminates the wide and long valley of Camonica. The great currents which have issued from the valleys of the Alps, and which have disseminated the blocks over the mountains and the plains, have not been confined to a portion only of the Alps, but are common to the whole chain on both sides; and the direction of those currents is always that of the valley which takes its origin in the glaciers in the primitive interior chain. For if the valleys take their origin in the calcareous mountains, and not in the primitive central chain, we shall never perceive any irruption of blocks which have proceeded from them. In regard to the cause, he considers it as certain that those currents are intimately connected with the raising up of the chain of the Alps effected by the augitic or pyroxenic porphyry. The primordial strata have proceeded from the interior, and have been elevated in mountains and chains of glaciers. The secondary strata have been forced aside, and raised at the same time; hence it is that they have been turned up against the primitive chain. The valleys of these mountains are the effect of the lateral rupture of the raised strata, and by this rupture the strata have been forced to occupy a greater space than otherwise they would have been able to cover. The valleys then, concludes Von Buch, were formed at the very time of the elevation of the primitive mountains. When the chain of the Alps was raised up, the waters which covered them were at the same time raised towards the summit; afterwards they fell again into their first bed, or at their first level through the lateral valleys of the second formation which opened at the same moment; they carried along with them the detached blocks, and deposited them on the mountains which had just been raised, and which thus came in contact with the atmosphere, in consequence of their elevation, and the return of the waters beneath their former level. The view here taken by Von Buch does not render necessary the retreat of the

hand, it is proved also, that the vast chasms of the mountains, as well as the cavities which form the

waters from our continents at the period of the raising of the primitive chain; all these convulsions may have taken place beneath the waters of the ocean without any permanent change of level. De Luc considered this great revolution in the same general manner, when he says, (Letter IV. § 35, note), "I trust that I shall succeed in producing a change in the ideas of De Saussure, by connecting the phenomenon of the scattered blocks, not with the *débacle*, or the retreat of the sea, but with the overthrow of our strata."

It is not only the valleys of the Arve and the Rhone, says Mr. J. A. De Luc, the younger, which exhibit the phenomenon of the dispersion of the blocks on the side of Switzerland, but also those of the Aar, the Reuss, the Limmat, and the Rhine, through which issued the great currents proceeding from the primitive chain. In this respect the observations and remarks of De Saussure, as contained in §§ 211 and 212 of his Voyages dans les Alpes, and erroneously criticised by our author in the first volume of his Travels in France, have received a full confirmation. "The fragments of rocks disseminated over our mountains have come thither by the great valleys of the Alps; those fragments are no where found in greater abundance, and at a more considerable height, than opposite those great valleys. The parts of Jura which are the most covered by them, directly correspond with the valley of the Rhone...... in all the breaches and gaps of the borders of the Jura, wherever deep ravines have opened an entrance to the currents which proceeded from the Alps, considerable accumulations of them are observable."

Mr. J. A. De Luc published, in 1827, at Geneva, a dissertation on this subject, entitled Mémoire sur le phénomène des grandes pierres primitives Alpines, distribuées par groupes dans le bassin du lac de Genève et dans les vallées de l'Arve. He has traced the blocks through the two valleys of the Arve and the Rhone up to their source, namely, the granitic needles of Chamouni. In attempting, in that memoir, to assign a cause for the phenomenon in question, he adopts an idea which had often struck De Saussure when contemplating the needles of Chamouni, and the sharp points with which they are bristled, viz. that they had been raised or set up by

basins of the lakes, must have existed before any rain could have fallen on our continents, that is to say, before they had been abandoned by the sea.

what he calls a *refoulement*, or some violent lateral pressure acting from below. This hypothesis was suggested to him by the circumstance of the vertical position and the parallelism of the plates of which these needles consist; it was equally suggested by the rising up of the surrounding mountains against the mass of Mont Blanc. In consequence of the *refoulement*, or the up-heaving of large masses of the strata, all the granitic peaks must have proceeded simultaneously from the interior of the earth; such rents and dislocations must have been occasioned by these commotions as to cause innumerable fragments to be detached, and at the same moment the waters of the ocean being violently impelled towards the west, must have flowed in that direction with such rapidity as to sweep along with them all the fragments, and have conveyed a great number of them to the most remote points where the waters have retained their velocity, namely, to a distance of thirty leagues and upwards. He considers that the transportation of the blocks must have taken place at the surface of the waters so rapidly, that the effect of gravity upon these masses must have been suspended by the violence of the currents. On the contrary supposition, the largest and flattest would have remained behind, and the smallest only have reached great distances. He is likewise inclined to believe, that they may have passed over the cavity of the lake Leman, being sustained by the liquid. The granites of the Rhone proceed from the peaks of the valley of Ferret, those of the Arve from the needles of Mont Blanc. The Petit Salève alone is covered with upwards of 1800 blocks, of all sizes, from three to forty-five feet (French) in length. All these have proceeded from the valleys of the Rhone and the Arve. At Cran, near Geneva, there is a block of petrosilex, 73 feet (French) in length, and 20 feet in height.

Since the publication of his Memoir, Mr. J. A. De Luc has communicated to the editor a different view, in regard to the cause of the dispersion of the blocks, from that which he had suggested therein. " Without having recourse," he says, " to the setting up of the needles at the period of the dispersion of the granite blocks, we might seek for the cause of this dispersion in that of the opening

22. Nevertheless, the rain waters incontestibly carry down some materials of the mountains; this

of the transversal valleys; for in the mass itself that constitutes the needles and the Mont Blanc, there are transversal valleys. I speak of the valley of the sea of ice with its ramifications, and of the basins which enclose the upper parts of the glaciers of Argentière and the Tour. Those elevated valleys are transversal, that is to say, they intersect at right angles the direction of the strata. Accordingly, therefore, the same cause which has opened the transversal valleys terminating in the plains, may have opened those which are in the centre of the Alps, and have thus furnished the enormous fragments of granite, the origin of which we have been investigating, as well as the fragments of petrosilex and conglomerate of Martigny, which have been supplied by the transversal valley of the Rhone." According to this view, the dispersion of the blocks would have taken place subsequently to the setting up of the needles, and at the time of the opening of the transversal valleys.

Treating of the transportation of the granite blocks, Mr. Bakewell acknowledges that "the action of mountain inundations, however great, seems inadequate to produce such effects:" but he deems it not improbable that the "blocks were originally deposited upon a more level soil, and have been raised up with the calcareous mountains at a subsequent period." This hypothesis, however, according to Mr. J. A. De Luc, is not in agreement with the phenomena which exhibit those blocks at every height, from the base of the mountains to their middlemost part. There are instances, indeed, where the blocks are met with only at a certain height, but this circumstance is owing to the violence of the currents, and the great elevation from whence the blocks proceeded.

The several facts, however, adduced by our author, from which he infers that in certain spots the masses of granite and other primitive stones have been ejected from within by explosions of expansible fluids compressed by the subsidence of the strata, are of too striking a nature to be overlooked in any explanation that is given of the phenomenon of the dispersed blocks. In the great revolution which brought our globe into its present state, many causes may have operated at the same time. At the periods when the chains of mountains underwent such enormous concussions that the ocean was

indeed being the necessary consequence of the state in which they were left when the sea retired; their abrupt and shattered sides were thus easily detached by the agency of external causes; which process still continues, though in a less degree. Now by its progress we find also direct means of ascertaining at what distance of time we ought to place the commencement of these operations; or the epoch when the sea abandoned our continents, and when the rains began thus to form rivers upon their surface.

23. For that purpose let us return to the lakes which are surrounded by abrupt mountains, such as those of Switzerland and Savoy. In these lakes, from the vertical sections of the strata, and the variety of their inclinations all around their basins, we readily conclude, that great excavations had been made before

heaved up from its bed, gazeous or aqueous fluids may have forced their way into some portions of the earth's surface, and carried off fragments of the inferior strata. Mr. Silberschlag, of Berlin, believed, with De Luc, that the masses of granite and other stones of the same class must, in several instances, have been ejected on the surface of the soil, a conclusion which he has drawn in consequence of having observed vast funnel-shaped cavities, resembling craters of volcanos, of which all the interior circumference was covered with the blocks, which appear to have been the focus of their explosion. See Travels in France, vol. i. § 154—156. See also §§ 284 and 322. In the table of geological facts, subjoined to the second volume of the Travels in France, &c. several phenomena are referred to, indicating the expulsion of the masses within.

"Povelsen," says M. Al. Brongniart, (Tableau des Terrains &c. p. 83, 1829), "states that granite blocks are found on the most elevated spots in Iceland, an island altogether volcanic, and very remote from any granitic country. Should the fact be well ascertained, it would become one of the most powerful arguments in favour of the singular hypothesis of De Luc."—Ed.

the rain had fallen on our continents. Let us fix on one of these lakes which we find situated at the outlet of a main valley, where a river pours into it the whole of the rain-waters, or of the snow which has fallen within a large extent of mountainous ground. This main valley is also bordered by eminences which present abrupt chasms on every side; and consequently, here is again a vast excavation in the strata, of which an immense quantity has been carried away at some preceding period. By tracing upwards the course of the principal river which flows at the bottom of this valley, we find on each side smaller rivers by which it is formed. These issue also, as well as their different smaller branches, from valleys, which, when we consider the abrupt sections of their sides, cannot themselves be any thing but excavations. The sides of these different valleys, even those that are most remote and highest in these mountains, are extremely tortuous, owing to chasms of different kinds, some of which, without traversing, form deep and wide furrows on them; while others divide them towards the top, thus separating their summits into distinct mounts, much resembling ruins. It is in these very numerous fissures, that the waters of the mountains are first collected, to descend into the valleys, and there it is that they make the greatest devastation; they carry with them the dust, and the small gravel, from between the broken stones, which cover the steep slopes: they undermine those slopes, formed of rubbish, which often slide down at once, and when either the rain or the fall of snow is abundant, the rolling of gravel, and even of large stones, may be heard at

the bottom of these torrents, which precipitate themselves down these abrupt and rugged channels.

24. Such are the operations which are performed throughout the whole extent of the mountains that furnish water to this river, which I have taken as an example: it is evident, that at each rain, or melting of snow, some materials are put in motion, part of which, carried down by the water, is finally conveyed by such rivers beyond the boundaries of the mountains; and this circumstance it is that has been supposed a sufficient cause for admitting, that thus, in the course of time, have been produced all the excavations I have described: but we shall now proceed to estimate as well the quantity of materials which our river, since it first began to flow, has subtracted from the mass of the mountains whence it proceeds, as the time which it has employed in carrying them down.

25. Whatever devastation the waters may make in the mountains, no part of what they propel in their greatest impetuosity can escape, except by the rivers; and that river, which I have been tracing through its whole course, reaches a lake, at the entrance of which, ever since it has been flowing, it has deposited even the smallest dust which its waters have carried off, in the whole space that they have pervaded. However troubled the water of such a river may at times be, it becomes limpid at some distance from its entrance into the lake; it continues so throughout all the rest of the lake, and in the same state flows out at the other extremity. Thus the whole quantity of materials, drawn from the entire circuit of these mountains, since it has begun to rain upon our continents, is

found collected at the entrance of the lake ; and there, by filling up a part of the original basin, it has formed a new land as horizontal as the water itself. How little proportion the filling up even of the whole basin would bear to the immense excavations which the waters pass in their course thither, I have already pointed out; here, however, we see only a very small part of it filled up, and it is this part which will serve us as a chronometer.

26. These new lands have been raised little by little, by means of the sediments which every new inundation has deposited upon their surface; and as they are usually very fertile, the inhabitants, whenever they find that they have arrived above the level of the usual floods, raise their banks against greater inundations, and cultivate them. We may trace the succession of some of these establishments, by the tradition of the inhabitants; and these afford a proportional measure by which, and by the inspection of the soil, we may judge of the whole. I have observed several of these chronometers, and if we consult only their immediate scale, that is, either the gradations of elevation in the almost imperceptible declivity of the new soil, or antiquity in its cultivation, proceeding in both cases upon effects produced in assignable times, many monuments of human art might ascribe greater antiquity to our continents, than we can deduce from these.

27. The space of time indicated by this measure, which thus appears so short, is yet farther shortened by another evident consideration. When the torrents were first formed in these ruinous eminences, to which we give the name of mountains, all their surfaces were

abruptly broken and fissured, and their chasms filled with debris. The running waters then were to clear their passage, and in proportion as they carried off the rubbish, more of it fell down from the shattered rocks. These waters must, therefore, in those times, have made more ravage, and carried with them a greater quantity of materials than they have ever done since; because their declivities have been softened by degrees, and bound by the roots of plants. We are assured of this process, because, wherever we dig to any great depth in the horizontal grounds, whether at the entrance of the lakes, or in the accumulations which the rivers have made in the valleys, we find the materials larger at the greatest depth, and gradually decreasing towards the surface. There we may perceive that, within a certain number of years, nothing has come down but sand, or small gravel. The greatest quantity of materials must then have been carried into the lakes at these times of the greatest ravages; and since the portions of new grounds made there within certain known times, belong to that period wherein the annual effect had been already much diminished, in applying this proportional measure to the total effect clearly observed, the space of time deduced from it, however short, must yet again be diminished on account of the much greater rapidity of the first progress. We should therefore arrive at a time manifestly too short, compared with other monuments of men, if we did not consider that it was necessary that the entrance of these lakes should have been filled up quite to the level of the water, and have formed itself in an inclined plane under it, before the new lands could begin to be produced; and that these

chronometers should mark the commencement of a period. But this time, which must be allowed for the first operations of the waters before the materials which they carried down could form new lands, is every where so limited by local circumstances, that among the great number of those new grounds that I have observed, whether in the lakes, or along the rivers, I have not found any which did not lead to the conclusion, that many ages have not elapsed since the rain began to operate upon our continents.

28. We had already seen, by immediate proofs, that the loose strata of our continents were formed, as they now are, by the sea: and that, since they have been abandoned by it, not many centuries have passed; and we have just seen, in confirmation of this first result, that, in the vast spaces included between such rivers, no one of these strata could have been formed from materials carried down from the mountains, inasmuch as all that has proceeded thence, and been deposited in the lakes, has not filled them. Whence then come those large fragments of stony strata, which, notwithstanding this, are every where found, on the hills, as well as in the plains, in the very spaces between these rivers, and likewise in their channels, far remote from mountains and lakes? This is one of the phenomena on which the authors of the systems I am now refuting relied the most; and here again we shall perceive that all these ancient systems arose entirely from ignorance of the facts.

29. We are not astonished to find great blocks of stone on the declivities of mountains, and in their valleys, when we see steep rocks at their summits; because the first and most natural idea is, that they

have been detached from the upper parts. When afterwards similar blocks are found in the channels of torrents, and then of rivers, still enclosed within the valleys, it may be thought that they have descended along the declivities, covered with other fractured stones, which have yielded to their weight: when again we see those blocks even in the plains, carried away by the idea that they must all proceed from the same eminences, we are apt to forget the lakes, and so many deep and tortuous channels, through which it was impossible for the waters to propel them. But time is called in to supply the want of means, and, from the habit of thinking that no other cause than running waters can have produced these phenomena, impossibilities are overlooked. Neither the enormous size of many of those blocks, (some of which are larger than that of granite, which was found in the marshes of Russia, and drawn at so great an expense to Petersburgh) nor the astonishing dispersion of smaller blocks, not only in the plains but on the hills; and the variety of their species in certain grounds, had been noticed: above all, it had not been perceived that gravel, of the same kinds of stone, is contained in many strata, mixed with marine bodies. Thus it was that men attached to an idea, in which, however, no features of truth are in any respect perceptible, refused to pursue the only method which could conduct them to the real causes; namely, that of ascertaining with precision all the characters of the phenomena: now the following instance of a dissemination of those blocks is alone sufficient to show how totally the opinion to which I am adverting is destitute of foundation.

30. When we are within the mountains of granite, and find on their declivities great blocks of that stone, down to the beds of their torrents, and of their rivers, it seems very natural to think that these blocks belonged originally to the broken rocks observed in the upper parts of the mountains; and thus gradually to ascribe the same origin to the blocks and pebbles of granite discoverable in the beds of some rivers, even in the plains. But let us quit the granite mountains, and proceed to some remote chain of mountains, whose strata are of calcareous stone, as the chain of Jura. In these mountains, where the strata are in the same disorder, and the heights present only broken rocks, we find also great blocks, not only on the declivities, but in the channels of the torrents, and of the rivers in the valleys: but do all these masses proceed from the rocks above? By no means: for, in the first place, these rocks are of calcareous stone, and the greater part of the blocks are of granite; and besides, these blocks are found up to the tops of rocks of an entirely different nature, and even sometimes in large heaps, which reduces the hypothesis to an absurdity [1].

[1] The following extracts from a Geological Memoir of the late Mr. Escher, the celebrated Swiss geologist, on this subject, strongly confirm the views of Mr. J. André De Luc, in opposition to those of our author. "In comparing," says Escher, "the granite blocks with the rocks which compose the high Alps, we find that in each basin they are identical with the rocks of the valleys, more particularly of the upper parts of the valleys, which form that basin." [By basin must be understood the whole enclosure (enceinte) of the mountains that supply torrents to one of the principal streams; so that a basin in the Alps comprises several valleys, all the waters of

31. When once we have been undeceived by this fact, indicative, no doubt, of some great cause, but

which unite to form one single river.] "Thus the blocks of the basin of the Rhine correspond with the rocks of the Canton of the Grisons; the blocks of the basin of the Limmath and of the lake of Zurich, correspond with the rocks of the Canton of Glaris; the blocks of the basin of the Reuss, the Aar, and the Rhone, correspond respectively with the rocks of St. Gothard, of Oberland, of the Canton of Berne, and of the Valais.

"In the Alpine valleys the blocks are accumulated at that point where the valley, after having become narrower, abruptly widens, whilst in the strait itself none are found.

"In the basin which separates the Alps from the Jura, the blocks are more or less scattered, even to the height of three thousand feet. But even here their dissemination follows some rule. They are the most numerous on the slopes opposite to the openings of the Alpine valleys, and often they are there found at a greater elevation than on the sides of the valleys whence they proceed.

"The slope of the Jura opposite the Alps, is almost every where scattered over with blocks; but they are accumulated in a striking manner opposite the defiles of the Alpine valleys. It is there also that they reach the greatest height, namely, that of four thousand feet above the level of the sea, whilst laterally they seldom rise above two thousand feet. On the spots where the chains or ranges of the Jura are lost in the plain, the blocks are disseminated in the valleys situated behind those chains. In the same manner, when a chain opposite the Alps presents a transversal opening, we meet with blocks in the valley which follow that chain. With respect to the parts of the Jura more remote from the Alps, the blocks are there found only in the sites directly opposite the openings of the first chain."

Escher accounts in a similar manner for the granite blocks found in the Val Travers, the Val St. Imier, &c.

Mr. J. A. De Luc, jun. has remarked, in addition to these facts, that the blocks in the different parts of the Jura are always of the same nature and of the same variety as the primitive rocks which

which excludes all idea of these blocks having been transported by running waters, we are no longer misled by appearances, even in those chains, at the centre of which arise huge rocks of granite; notwithstanding their ruined state, and the apparent probability that the blocks scattered on the sides, and in the bottom of the valleys, have been detached from these upper rocks, we begin to doubt whether they have proceeded thence; and we are confirmed in that doubt by the difference frequently observable between the granite of the blocks below and that of the rocks above. A remarkable instance of this is recorded at the 290th page of the 38th volume of the Journal de Physique, in a Memoir by Mr. PATRIN, who points out in the mountains of Asia, the same circumstance respecting those blocks which I have now been describing in those of Europe. But this great monument of the revolutions which took place in our globe at some period anterior to the present state of things, strikes us still more when we come to remark, that the granite blocks and other stones of a quartzose nature, are found, not only in the parts of those chains of mountains where granite is the prevailing rock, but also on the declivities and at the bottoms of the valleys, as well of the schistose as the calcareous chains, which follow the former outwardly, and in situations

constitute the part of the Alps directly opposite. This fact appears decisive. Our author was mistaken when he affirmed that, in the basin of Geneva, species of rocks foreign to the Alps were met with. The fact is, that all the species and varieties of rocks disseminated in the neighbourhood of Geneva, are again found in their place in the valleys and mountains of the Valais, and in those which border the course of the Arve.—ED.

where it is impossible that those blocks should have fallen from the upper portions of the mountain.

32. I shall now, Sir, give an example which, from its vicinity, must be familiar to you. The Hartz is but a small chain of mountains, of which the granitic part is the Blocksberg, against which rests the Bruchberg, a schistose mountain, separated from the former eminence only by a small inflection, forming a high glen. On another side is Rehberg, extending also as a lower branch of the Blocksberg. This last prominence consists entirely of granite blocks; and it is of such an extent, and so little below Blocksberg, that it is impossible to conceive that these blocks could have descended from thence. Whoever shall observe this scene of disorder, will acknowledge, that there is not any cause actually operating, which could, in any length of time, have produced such an accumulation of these blocks. But what, in this groupe, is most striking, and excludes every idea that this disorder could proceed from any cause belonging to the present order of things, is, that Bruchberg, which, as I said, joins also to Blocksberg, and is schistose in its structure, is covered with blocks of a quartzose stone, no stratum of which is to be found in any part of those mountains; and these blocks, as well as those of granite, are scattered also on many mountains of calcareous stone, as well as in the plains, and proceed from a class of strata, whole mountains of which are found in other countries, as in Veteravia, and in England [1]. The blocks of granite in the mountains

[1] See the author's tenth Letter to Mr. de la Métherie, in the Journal de Physique, tom. xxxvi. pp. 332—351. 1790.—Ed.

of the Hartz, are traced upon the summits, on the declivities, and at the bottom of the valleys of the schistose ridges, as also of the calcareous mountains which rest against these last; and they abound in all the heaths of Lower Saxony and Westphalia, on the hills, in the plains, and even to the very coast of the sea.

33. Lastly, to prove that we never should ascribe the blocks of stone found on the sides of the mountains to the broken rocks above, without examination, I shall cite another instance of a different kind, also not far from Gottingen. On the declivities of the calcareous mountains of Hildesheim, between Eim and Eisbeck, I have observed immense loose and insulated masses of a calcareous stone in strata totally different from the strata of the loftier parts of those mountains; and at the same time, I have found fragments of granite, and other stones equally foreign from the nature of these mountains, on their declivities, and at the bottom of their valleys[1].

[1] It has now been ascertained that the blocks spoken of in this and the preceding Section, have a northern origin, and have chiefly proceeded from Sweden, Finland, and the neighbouring islands. See Bibl. Univ. (Sciences et Arts) vol. xxxix. pp. 217—237. See also "Notice sur les blocs de roches des terrains de transport en Suède," par M. Alex. Brongniard (Annal. des Sciences Naturelles, tom. xiv. p. 5. 1828.)

The most numerous are several varieties of gneiss, granite, syenite, grunstein, and porphyry. Sometimes hornstone, siliceous schist, petrosilex, grunstein porphyry, siliceous conglomerate, quartzose rock, and quartzose sand-stone are met with. Of those which are limited to certain regions, are calcareous and marly stones, which enclose orthoceratites, trilobites, and other petrifactions, and which are found only in Mecklenburg and Pomerania. The rocks of

34. I have cited these particular facts as examples of the general phenomenon; for nothing is more

which all these stones are composed, correspond so perfectly with the Swedish rocks, that we may, with respect to several of them, point out the districts whence they are in all probability derived.

On adverting to the fragments of rocks extraneous to the soil, scattered over the plains of the north of Germany, as well as throughout Denmark, Russia, and all the vicinities which border the coasts of the Baltic Sea to the south, it is remarked that their direction is principally from north to south, inclining sometimes to the east, and that it is in this direction they are found in greatest abundance. The blocks foreign to the soil found in the eastern parts of England, says Professor Hausmann, proceed most probably from Norway. The same geological phenomenon occurs over a very considerable surface in North America; and from the observations of Hayden, it would appear that the blocks have been transported in a direction from north-east to south-west. Mémoire sur l'origine des Pierres éparses dans les contrées sablonneuses de l'Allemagne Septentrionale, par M. le conseiller Hausmann, avec des notes et des remarques critiques par J. A. De Luc. Bibl. Univ. vol. xxxix. p. 229.

Mr. J. A. De Luc, the younger, considers that it is necessary to admit two transportations of stones, foreign to the soil in the north of Germany, which must have occurred at two different epochs; to the first belong the blocks and gravel enclosed in the beds of marl,—to the second, those found at the surface of the soil, and which are far the most numerous. He grounds his opinion, partly, on a Memoir of Dr. Bruckner, of Neu-Strelitz, which treats of the formations of Mecklenburg, wherein that author distinguishes the formation which encloses the blocks and gravel, from that which is composed of marl covered with sand and clay. The last author adds, that in the sand intermixed with the marl, calcareous fossils, primary pebbles, and also bones are met with.

Mr. J. A. De Luc, jun. is of opinion, that the blocks which have proceeded from Sweden, and which are dispersed in such prodigious numbers over the plains of northern Germany, are to be referred to the last great terrestrial revolution, thus differing from Professor Hausmann as to the necessity of assigning to it a different epoch

common than, on mountains, hills, and plains, and within the loose strata on the surface of the soil, to

from that at which the debris of the Alps have been transported. He derives his proofs from our author's Geological Travels in the north of Europe.

The numerous observations of De Luc testify indeed, that this phenomenon of the dissemination of the stones throughout the north of Germany, and the continental provinces of Denmark, is in a great measure limited to the surface of the soil, and that there it is exhibited in all its magnitude. Now, in such a situation, it is to the last terrestrial revolution only, that we can ascribe their transportation, and accordingly to the same which has effected the transportation of the Alpine blocks. Mr. J. A. De Luc considers that the same cause to which must be assigned the disruption of the rocks, and the consequent immense quantity of fragments, has, in its operations, impressed upon the waters of the ocean movements sufficiently violent and extensive for their transportation to such great distances, which, in respect to the blocks of the north, may be calculated at a hundred and fifty, and even two hundred leagues. This cause can be looked for only in the interior of the globe; there indeed we may find agents of adequate power to convulse and overthrow the surface. No external cause, he thinks, was of sufficient force to rupture the mountains and rocks to such a degree as to reduce them into myriads of fragments; currents of water, whatever velocity we may suppose them to possess, cannot be productive of such effects, and no other external agent is easily conceivable. Currents of water, though they carried away the stones, have not fractured the rocks. See Bibl. Univ. ut suprà.

In the peninsula of India, Hydrabad (latit. 17° N.) is entirely composed of granite; enormous masses of that rock are every where dispersed over the surface, and sometimes accumulated in heaps. Even at the first aspect it would be naturally concluded that this country had been exposed to the agency of some great destructive force which had fractured and torn asunder the hills, and scattered their fragments over the neighbouring plains.

In the province of Nyland, constituting a part of Finland, and in the vicinity of the new town of Louisa, Wraxall traversed a space of three leagues, where, he says, the earth may almost be said to

find blocks, or smaller fragments and gravel, belonging to stony strata, known to exist in some mountains

have disappeared from his view, "so completely was it covered with stones, or rather rocks; for many of them from their magnitude may well merit that appellation. The road, compelled to respect these formidable impediments, performs a thousand tortuous evolutions in order to avoid them, and serpentines beautifully for many miles. Neither cultivation, nor population, can possibly exist among such a wilderness of stones." Wraxall's Tour round the Baltic, &c. p. 215.

The particular manner in which this powerful cause has operated might possibly be determined, were the internal and external structure of the hills, the mountains, and even the plains of Sweden which are composed of the same rocks of which the debris are disseminated at such great distances, minutely studied. It would be ascertained whether those mountains and hills have been subverted and ruptured, elevated or depressed; whether the great disorder which prevails throughout their masses can be explained only by a force proceeding from the interior.

The granitic hills descend from Smaland down to Carlscrona. The islands of Carlscrona, and all the others which border the coast of the province of Bleking, the isles of Bornholm, and Christiansoe, appear to be fragments of a vast granitic country which had been overturned and fractured in a multitude of places. To those several tracts attention should be directed in order to discover the mode in which the cause that has detached so many fragments, has exercised its action.

In a Memoir, serving as a sequel to the one here noticed, and read before the Society of Natural History at Geneva, Mr. J. A. De Luc treats of the dispersion of some particular kinds of primary and transition rocks. "In order," he says, "that a correct notion of this dispersion may be formed, it is requisite to know the dimensions of the space where it has been effected. Our basin is fourteen or fifteen leagues in length, from Lausanne to the mountain of Vouache, or to the passage of the Ecluse. Its breadth varies from three to five leagues and a half; it is yet more considerable at Morges and Lausanne, being from six to seven leagues. Now within that space, and on all its points, we find pebbles and fragments of the same kinds of rocks. This I have sufficiently ascer-

elsewhere, but none of which is found in that country, either in eminences or under the soil of the plains, at

tained by means of excursions in every direction, and as far as the basis of all the mountains." Of the several kinds of rocks which came more especially under his observation, may be mentioned the two following:—"The first is the euphotite, a rock composed of *jade* (compact feldspath) and diallage. The *jade*, according to De Saussure, (§ 1943) characterizes the borders of our lake and of the Rhone, to the point where the latter ceases to be enclosed between the Alps and the Jura. I shall observe that the compact feldspath characterizes not only the borders of the lake and the Rhone, but also the whole extent of our basin, to the basis of the surrounding mountains. I have met with them at the foot of Salève, Voirons, Vouache, and all along the Jura from Lausanne, passing through Morges, Gimel, Burtigny, &c., and not far from Fort de l'Ecluse; as likewise in all the *nants* or beds of rivulets between Chanci and the Vouache. The village of Chanci is three miles to the south-west of Geneva. We find pebbles of jade in all the environs of our city. The jades are found, not only in pebbles and small blocks, but in very large blocks from twelve to seventeen feet in length. The rock of jade belongs to the mountains of the Valais, situated between the Rhone and the valley of Aoste.—The second rock is the conglomerate of Trient, of Martigny, and Derbignon. (See the Travels of De Saussure, §§ 689. 691. 693. 698. 1072. 1075, 1076.) I have met with pebbles and blocks of this conglomerate from Moudon to the small stream of Alondon, near Russin, which is a distance of twenty-one leagues in a direct line,—and on all the points of the breadth of the basin. As for instance on the Petit Salève near Mournex; on the summit of the Coteau de Boisy, four leagues to the north-east of Geneva; in the vicinity of Yvoire, near the lake. In all these places large blocks of the conglomerate are met with. In regard to the *galets* or pebbles of this pudding-stone, they are found every where; at the basis of the Jura, from Cossonay, Gimel, the summit of the Côte de Rolle, &c. as far as St. Jean de Gonville, three leagues to the west of Geneva; in the middle of our basin, at Dovaine, Nerni, &c.; on the borders of the lake under Cologni, the banks of the Arve, &c.; on the eastern coast of our lake, at the basis of the Voirons, Etrembières, &c." Three other kinds of rocks equally widely dispersed are men-

any attainable depth. If the rivers, to which it was usual formerly to attribute this great phenomenon, sometimes exhibit a great quantity of such fragments, it is merely because in hollowing those channels through loose strata, they have carried with them the sand and other kinds of dust, leaving behind, at the bottom of their beds, all the stones that could not float along with them: and as a proof of this, wherever the rivers have their channels covered with blocks or gravel, dissimilar to the stony strata of the country, the same sorts of stones are found in the loose strata all around, even on the hills, where the rivers never could have passed. Thus all the notions of the great ravages produced by the rain-waters upon our continents since their existence, have been mere illusions; and we must seek some other cause for the phenomena I have now described.

35. The following, Sir, are the facts which I have here determined, and of which the details may be found in my works. 1st. The whole mass of our continents is composed of strata of different substances,

tioned in the Memoir, and the author makes, in conclusion, the following remark:—"So extensive a dispersion of several of these rocks, indicates the agency of an extraordinary force or power, making its way through the rocks with a violence which the most solid masses could not resist. It was the same force that opened the transversal valleys, not by gradual excavations, but by a sudden effort which carried off large masses, and dispersed their fragments, as if by explosion. When this power began to act, and forced its way through the outlet of the valley of the Rhone, it divided itself into a great number of diverging lines which comprised a large space in width, and extended to the basis of the Jura; similar to a great current, which issuing from a narrow passage, suddenly spreads over an extensive plain, where it occupies a considerable breadth." Ed.

the principal kinds of which have almost every where the same order of superposition. 2dly. After the first kinds of strata, visibly the most ancient, and containing no organic bodies, we find other strata wherein such bodies are contained, and these change their species in the strata of different kinds which are placed one above another. 3dly. We find remains of terrestrial animals and vegetables among these organic bodies: but in the great majority of these strata, and even in the loose strata at the surface of our soil, the most considerable part consists of marine bodies. 4thly. Although it is thus certain that our strata were formed in the sea, (which necessarily implies that they must have been accumulated in a continuous manner, and in a situation nearly horizontal) they are actually broken, overthrown, and sunk in great masses, in such a manner that the whole surface of our continents exhibits the most ruinous appearance. 5thly. The violent causes which have thus disordered our strata preceded some great revolution, by which our continents were left dry, and thus submitted to the operation of such causes as are at present known. 6thly. This great event was not many ages prior to the times traced back by human monuments.

36. Such are the general facts which, as certain and determined effects of causes that have formerly operated on our globe, mark out the task of the geologist; and, to embrace the whole subject, he must of necessity explain, 1st. The origin of the substances of which our strata are composed. 2dly. The cause of the successive differences which we observe in these substances. 3dly. Why it is that remains of terrestrial animals and vegetables are found, in some strata,

intermixed with those of marine animals. 4thly. Whence proceeds the disorder of these strata, and the dispersion of their fragments. 5thly. By what means their ruins are now found above the level of the sea. 6thly, and finally, To what changes these ruins have been exposed, from causes actually known, since they have emerged from the sea.

This, Sir, is the task I have undertaken in my Letters to the Journal de Physique; and, in my ensuing Letters, I shall have the honour to lay before you a sketch of the causes to which I attribute this series of events, as well as of their connection with what Revelation has taught mankind respecting the history of the earth and of the universe.

I have the honour to be, &c.

LETTER II.

Analysis of Geological Phenomena, leading to a determination of their Origin.

Windsor, June 27, 1793.

I HAVE stated in my first Letter, from the most striking phenomena of the earth, the task traced out for those who undertake its history, and which I have prescribed to myself accordingly. But before entering upon it, I shall offer a few remarks upon the conduct of some persons of a high rank among naturalists respecting this subject.

1. It is an assertion we very frequently hear made, that human nature is becoming daily more enlightened. And, it may seem to be an assertion too true to leave room for any doubts: it is, however, equivocal, and to admit it without proper examination, would lead to the most mischievous consequences. To this point, I shall now direct my observation.

And first, it is essential to remark, that knowledge, considered as the result of the observations and enquiries of man, divides itself into two branches, different in their nature, and which do not always keep pace with each other: the one is, the collection of axioms

and facts, which are in themselves independent of man, and are supplied from objects without us; the other is, the collection of theories or systems deduced from these data. It is therefore under these two points of view, separately considered, that we must examine the scientific progress of any particular age.

2. Moreover, in such an examination, the general object of knowledge presents itself under two very different aspects; for we must be careful not to confound that portion of real knowledge which we may find among a select number of individuals, with the sum of what may be found diffused among the rest of mankind; nor the judgment pronounced on their discoveries, by those to whom they are due, with the mode whereby they are made known by those who merely repeat them. Even when new discoveries take place, they are seldom at first pure from error; time is required that they may be examined, corrected, and accurately determined, by a certain class of individuals; to this test they must be submitted before they can be entitled to be received into the stock of true knowledge. But, very often, the new ideas which are disseminated, are either but glimmerings of light, or perhaps false views of new objects, which, for a time, and occasionally in circumstances the most important to mankind, is worse than a total want of knowledge. When our age is complimented with being more enlightened than preceding ones, allusion is made to a knowledge that we find generally diffused; and consequently it is on this ground, that I am called to examine the question.

3. In every age, the learned form a distinct class of men to whom science is supposed to owe its preserva-

tion and progress, and whose peculiar province it is to instruct others in those matters, which for want either of time, or opportunity, or suitable means, they are unable to discover and study themselves. If their instructions were limited to facts, without the addition of commentaries, science thus disseminated among mankind, would, while it augments, always continue real; but the human mind is prone to generalize; to conclude that to be common and constant, which has only been occasionally observed, in order to connect it sooner and more easily with some ideas of causes; and thus it frequently happens that when new discoveries are made, facts are so blended with hypotheses, that at first they are confounded together: so that they who cannot or will not receive any instruction but such as is easy, and requires little attention and reflection, can hardly fail to fall into error. It is plain, then, that we should judge hastily to pronounce an age enlightened, merely because we hear much talk of knowledge in it; it is necessary first to ascertain in what this knowledge consists.

4. The more facts multiply at any particular period, the more time is required to disengage these new facts from the several hypotheses (implied or expressed) with which those who first announce them to the world are apt to accompany them. Thus the abundance of facts which may be collected in any particular age, must not be considered in itself as a sign of a proportionable increase of true knowledge: it may be diminished, and even false views substituted in its stead, by want of precision in distinguishing facts and consequences from the hypotheses that accompany

them; a fault very common in our times. However, this discrimination is a duty strictly incumbent on those who announce new discoveries; for the distinction is difficult for those who have not themselves the means of observing; they cannot accordingly have a correct perception of those parts of the whole presented to them, respecting which they ought to form their own judgment.

5. Though in all cases, this care to discriminate facts from the commentaries made upon them, ought to be inculcated upon these instructors of the world, out of respect merely to those whose attention they seek to command, it becomes a duty more and more urgent in proportion as the ideas they propagate may have an influence on the conduct or happiness of mankind. On this point morality more particularly requires that we should always announce what effects the consequences we deduce from certain facts are calculated to produce in the minds of men; in order that those who are inclined to consider them, may proportion their attention to the real importance of our systems.

6. These, Sir, I am aware are ideas and maxims, so self-evident to enlightened understandings, that they may appear trivial at first sight; but many men, reputed learned, have manifested by their conduct, a forgetfulness of maxims the most simple, and duties the most binding; and as I have, in this last respect, much to reproach them with, I shall guard against a similar error myself, by fore-warning all those new readers, whom, under the auspices of your name, I shall no doubt obtain, "that the Treatise of Geology,

of which I have undertaken to give a sketch in these Letters, tends to establish the certainty of the Mosaic Revelation."

7. And here I would ask, have those among our geologists, who have for a long time been forming systems, which, in their consequences, tend to overthrow this Revelation, acted with similar candour? Have they, I say, announced this tendency, that their auditors might put themselves on their guard from the first, by reason of the remote consequences of such theories? I am not ignorant what defence might be attempted to be set up for their justification. They published their works (it will be said) in times when such an avowal would have excited the popular clamour against them, and drawn down on them the vengeance of governments. However justifiable this excuse may be in some cases, it will be impossible to find any, either for the authors themselves, or for those who have blindly propagated these theories, when it is generally understood that they have decided at random upon questions, which, from their nature, require the most profound study; and that, abusing their reputation as enlightened men, they have insensibly seduced the minds of others into errors the most dangerous.

8. In order to heighten the value of the knowledge attributed to our age, and to exalt the merit of that class of instructors I allude to, it has been constantly repeated, in compliance with their maxims, that a state of ignorance is the most dangerous condition of man. But before we flatter men's vanity with regard to their knowledge, and thus lull them to rest with respect to the dangers that may arise from false

learning, (dangers much greater and more lasting than those to which ignorance can expose them) we should do well to examine thoroughly what it is which they call knowledge. I must even go so far as to observe, with regard to many of those who contribute to propagate this illusion, that they ought to have begun by acquiring such information as might have qualified them to make this examination respecting a subject so important as that of the public faith, the foundation of morality in Europe, and throughout a great part of the rest of the world. Geology was brought in evidence against the Mosaic Revelation by means of inferences, which the readers of certain systems were induced to draw from them. Now geology opens into the widest field of phenomena that nature affords to man in one connected whole; and there is accordingly no science respecting which a man who has reflected on the difficulty of avoiding error in complex researches, ought to be more firmly on his guard. By what means, then, have so many persons been brought to admit, contrary to the primary basis of the public faith, systems on the truth of which they were incapacitated from forming a judgment? A detailed reply to this question would take me too far from my subject; I shall therefore content myself with pointing out one of the means which directly applies to it.

9. The circulation of systems of natural history, contrary to the Mosaic revelation, has been greatly extended, by representing them as wholly unconnected with Christianity, the certainty of which, it was said, was independent of that of the Jewish religion, or at least of the first chapters of Genesis; an assertion

which even a number of Christian ministers were made to believe. It is thus that a great number of individuals have allowed themselves to be carried away by this pretended natural science, without being aware of its tendency; it is thus that it has become a kind of fashion; that its general results, exhibited as demonstrated propositions, have been circulated throughout all classes of society; and that, lastly, the time has arrived when the greater part of those who pretend to some information, even among the Jews, would have been fearful of incurring the charge of ignorance, had they not sided with those who consider as a fiction the first of our sacred books. The consequence has been, that men of letters, without being naturalists themselves, but putting implicit faith in what was so positively asserted to be the evidence of nature, have more openly and more successfully revived some historical and moral arguments, to which both Jews and Christians have long ago replied, and which would never have had any influence on the bulk of mankind, if there had not been an appearance of an appeal to nature. Neither will I reject her evidence; I will only show it, such as it is, to those who have suffered themselves to be carried away by misrepresentations of it.

10. All these theories of the earth, which are repugnant to the Mosaic history, contain one common proposition, and which also in all of them is the principal argument made use of, namely, " that our continents are of very great antiquity." This would indeed be a decisive argument against that part of the account of Moses, who ascribes the origin of the actual population of the earth, to a family saved from a general

deluge, and the generations and history of which he connects with the times in which he wrote. But the more important this geological proposition was, the more indispensable was it that it should be proved by observations made immediately on the continents themselves. Nevertheless, it had not yet occurred to any one to examine our continents with this view: an attempt had indeed been made to account for their origin, it being very evident that they are not so ancient as our globe itself, and that they must have been formed, as we find them, by some physical cause; but the different causes to which they were assigned would have operated so slowly, that the whole series of the historical ages were not sufficient to produce any quantity of the known effect, within a known time. For this reason, therefore, conceiving it to be impossible to limit, by immediate observation, the antiquity of the present state of our globe, no other bounds were set to it than were demanded by systems. Accordingly, this notion of the prodigious antiquity of our continents, which we find peremptorily opposed to the account of Moses, does not proceed from facts; it is brought forward only as an hypothesis necessary to other hypotheses.

11. Let us, however, for one instant admit the opinion of these geologists, that, "we should search in vain in our continents themselves for documents that might serve to determine their age;" then, indeed, if a period of time excessively long, granted by hypothesis to the causes they pretended to have discovered, could have explained the whole scene of geological phenomena, it would have been natural to admit this hypothesis, the time past being without

limits. Wherefore, when I examined these systems in my Letters on the history of the earth and of man, I at first made no objection with regard to time; I dwelt only on the supposed causes; but, when I came to compare in respect to each the effects attributed to it, with what it was to explain, I easily made it evident, that none of them would have been thought of, had the inventors of them been ever so slightly acquainted with geological phenomena; for there is not one of those causes, whatever portion of time may be allowed it, that can account for the most common of these phenomena.

12. Nevertheless, this hypothesis of the immense antiquity of our continents, so gratuitous in itself, and so useless, since it supplies us with no causes competent to explain the phenomena of the earth, is the sole argument that has been opposed (as the evidence of nature) to what Moses has related respecting the renovation of the human race, owing to a great revolution, which, at no very distant era, affected the whole globe; while, on the contrary, after having shown, by refuting the systems of these geologists, how inconsiderate their attack of this article of the public faith has been, I adduced various decisive phenomena, as the evidence of nature, to prove, that our globe must necessarily have undergone that revolution, at the [illegible] stated by Moses, since our continents are not, [illegible] than his history represents them to be:
[illegible]nce, considering the magnitude of the
[illegible] striking confirmation of this reve-
[illegible]ed out some of these phenomena
[illegible], and am now, Sir, going to show
[illegible]xpect a successive multiplication

of evidences on this head, to the great astonishment of those who had suffered themselves to be led astray by false geological knowledge, and who will ultimately, no doubt, seriously regret it.

13. Egypt and India are the countries from which, in consequence of ignorance in regard to geological facts, and the difficulty of verifications, had been derived the greatest number of chronological fables, founded on the obscure evidence of some uninformed or presuming sectarians. But the influence which writers who had transmitted these fictions, intermingled with their own conjectures, have been allowed to obtain, is now daily giving way to the surer authority of naturalists, who build on the more certain evidence of phenomena. M. le Chev. de Dolomieu, whose opinion I have already quoted in my former Letter, has just published a Memoir relating to Egypt, in the Journal de Physique, which is of high importance to the history of the earth. In this Memoir, that attentive observer compares the progress of natural phenomena with some of those stupendous works of art which were executed at those periods when that country was very populous; works, intended either to distribute water over the country, or to retain it in particular places in times of inundation, for the use of agriculture in seasons of drought. The same wants had suggested the same expedients in the peninsula of India, where indeed, as would appear from a description of this country, which I have just received, they might, perhaps, have had their origin. Now, is the fancy of man at liberty to assign to these works, how great soever they may be, an arbitrary antiquity? By no means; for the description that M. de Dolo-

mieu gives of the operation of natural causes in these countries, and of the course of their progress, proves them to be similar to what we may observe, with all their concomitant circumstances, in many countries in Europe; and M. de Dolomieu, after having entered minutely into this comparison, expresses his astonishment that writers, who passed for geologists, could have eagerly supported for so long a time, as if striving to out-do each other, this opinion of the high antiquity of the present state of our globe, contradicted as it is by a multitude of phenomena every where before their eyes.

14. If we look into the history of the opinions that have been formed relative to our globe, we shall find, that it is the organized bodies contained in our mineral strata, which gave birth to geology. The first idea suggested by this surprising phenomenon, and which, generally considered, remains incontestable, is, that our globe must have undergone some great revolution. In those times when the revelation of Moses had not yet been attacked among those people who profess to acknowledge it, it was likewise very natural to conceive, that the revolution that was thus made manifest to our senses, was the deluge described in our sacred books, the tradition of which remains also among all the Asiatic nations. But the study of geological phenomena being then only in its infancy, and many errors being mixed with the earliest descriptions of them, the different connections those first geologists thought they had established between the visible phenomena and that great event, have been successively set aside as knowledge has advanced. It is owing to this that other naturalists, confounding

deluge, and the generations and history of which he connects with the times in which he wrote. But the more important this geological proposition was, the more indispensable was it that it should be proved by observations made immediately on the continents themselves. Nevertheless, it had not yet occurred to any one to examine our continents with this view: an attempt had indeed been made to account for their origin, it being very evident that they are not so ancient as our globe itself, and that they must have been formed, as we find them, by some physical cause; but the different causes to which they were assigned would have operated so slowly, that the whole series of the historical ages were not sufficient to produce any quantity of the known effect, within a known time. For this reason, therefore, conceiving it to be impossible to limit, by immediate observation, the antiquity of the present state of our globe, no other bounds were set to it than were demanded by systems. Accordingly, this notion of the prodigious antiquity of our continents, which we find peremptorily opposed to the account of Moses, does not proceed from facts; it is brought forward only as an hypothesis necessary to other hypotheses.

11. Let us, however, for one instant admit the opinion of these geologists, that, "we should search in vain in our continents themselves for documents that might serve to determine their age;" then, indeed, if a period of time excessively long, granted by hypothesis to the causes they pretended to have discovered, could have explained the whole scene of geological phenomena, it would have been natural to admit that hypothesis, the time past being without

limits. Wherefore, when I examined these systems in my Letters on the history of the earth and of man, I at first made no objection with regard to time; I dwelt only on the supposed causes; but, when I came to compare in respect to each the effects attributed to it, with what it was to explain, I easily made it evident, that none of them would have been thought of, had the inventors of them been ever so slightly acquainted with geological phenomena; for there is not one of those causes, whatever portion of time may be allowed it, that can account for the most common of these phenomena.

12. Nevertheless, this hypothesis of the immense antiquity of our continents, so gratuitous in itself, and so useless, since it supplies us with no causes competent to explain the phenomena of the earth, is the sole argument that has been opposed (as the evidence of nature) to what Moses has related respecting the renovation of the human race, owing to a great revolution, which, at no very distant era, affected the whole globe; while, on the contrary, after having shown, by refuting the systems of these geologists, how inconsiderate their attack of this article of the public faith has been, I adduced various decisive phenomena, as the evidence of nature, to prove, that our globe must necessarily have undergone that revolution, at the time stated by Moses, since our continents are not, in fact, older than his history represents them to be: which circumstance, considering the magnitude of the event, is of itself a striking confirmation of this revelation. I have traced out some of these phenomena in my former Letter, and am now, Sir, going to show you, that we may expect a successive multiplication

deluge, and the generations and history of which he connects with the times in which he wrote. But the more important this geological proposition was, the more indispensable was it that it should be proved by observations made immediately on the continents themselves. Nevertheless, it had not yet occurred to any one to examine our continents with this view: an attempt had indeed been made to account for their origin, it being very evident that they are not so ancient as our globe itself, and that they must have been formed, as we find them, by some physical cause; but the different causes to which they were assigned would have operated so slowly, that the whole series of the historical ages were not sufficient to produce any quantity of the known effect, within a known time. For this reason, therefore, conceiving it to be impossible to limit, by immediate observation, the antiquity of the present state of our globe, no other bounds were set to it than were demanded by systems. Accordingly, this notion of the prodigious antiquity of our continents, which we find peremptorily opposed to the account of Moses, does not proceed from facts; it is brought forward only as an hypothesis necessary to other hypotheses.

11. Let us, however, for one instant admit the opinion of these geologists, that, "we should search in vain in our continents themselves for documents that might serve to determine their age;" then, indeed, if a period of time excessively long, granted by hypothesis to the causes they pretended to have discovered, could have explained the whole scene of geological phenomena, it would have been natural to admit that hypothesis, the time past being without

limits. Wherefore, when I examined these systems in my Letters on the history of the earth and of man, I at first made no objection with regard to time; I dwelt only on the supposed causes; but, when I came to compare in respect to each the effects attributed to it, with what it was to explain, I easily made it evident, that none of them would have been thought of, had the inventors of them been ever so slightly acquainted with geological phenomena; for there is not one of those causes, whatever portion of time may be allowed it, that can account for the most common of these phenomena.

12. Nevertheless, this hypothesis of the immense antiquity of our continents, so gratuitous in itself, and so useless, since it supplies us with no causes competent to explain the phenomena of the earth, is the sole argument that has been opposed (as the evidence of nature) to what Moses has related respecting the renovation of the human race, owing to a great revolution, which, at no very distant era, affected the whole globe; while, on the contrary, after having shown, by refuting the systems of these geologists, how inconsiderate their attack of this article of the public faith has been, I adduced various decisive phenomena, as the evidence of nature, to prove, that our globe must necessarily have undergone that revolution, at the time stated by Moses, since our continents are not, in fact, older than his history represents them to be: which circumstance, considering the magnitude of the event, is of itself a striking confirmation of this revelation. I have traced out some of these phenomena in my former Letter, and am now, Sir, going to show you, that we may expect a successive multiplication

deluge, and the generations and history of which he connects with the times in which he wrote. But the more important this geological proposition was, the more indispensable was it that it should be proved by observations made immediately on the continents themselves. Nevertheless, it had not yet occurred to any one to examine our continents with this view: an attempt had indeed been made to account for their origin, it being very evident that they are not so ancient as our globe itself, and that they must have been formed, as we find them, by some physical cause; but the different causes to which they were assigned would have operated so slowly, that the whole series of the historical ages were not sufficient to produce any quantity of the known effect, within a known time. For this reason, therefore, conceiving it to be impossible to limit, by immediate observation, the antiquity of the present state of our globe, no other bounds were set to it than were demanded by systems. Accordingly, this notion of the prodigious antiquity of our continents, which we find peremptorily opposed to the account of Moses, does not proceed from facts; it is brought forward only as an hypothesis necessary to other hypotheses.

11. Let us, however, for one instant admit the opinion of these geologists, that, "we should search in vain in our continents themselves for documents that might serve to determine their age;" then, indeed, if a period of time excessively long, granted by hypothesis to the causes they pretended to have discovered, could have explained the whole scene of geological phenomena, it would have been natural to admit that hypothesis, the time past being without

limits. Wherefore, when I examined these systems in my Letters on the history of the earth and of man, I at first made no objection with regard to time; I dwelt only on the supposed causes; but, when I came to compare in respect to each the effects attributed to it, with what it was to explain, I easily made it evident, that none of them would have been thought of, had the inventors of them been ever so slightly acquainted with geological phenomena; for there is not one of those causes, whatever portion of time may be allowed it, that can account for the most common of these phenomena.

12. Nevertheless, this hypothesis of the immense antiquity of our continents, so gratuitous in itself, and so useless, since it supplies us with no causes competent to explain the phenomena of the earth, is the sole argument that has been opposed (as the evidence of nature) to what Moses has related respecting the renovation of the human race, owing to a great revolution, which, at no very distant era, affected the whole globe; while, on the contrary, after having shown, by refuting the systems of these geologists, how inconsiderate their attack of this article of the public faith has been, I adduced various decisive phenomena, as the evidence of nature, to prove, that our globe must necessarily have undergone that revolution, at the time stated by Moses, since our continents are not, in fact, older than his history represents them to be: which circumstance, considering the magnitude of the event, is of itself a striking confirmation of this revelation. I have traced out some of these phenomena in my former Letter, and am now, Sir, going to show you, that we may expect a successive multiplication

deluge, and the generations and history of which he connects with the times in which he wrote. But the more important this geological proposition was, the more indispensable was it that it should be proved by observations made immediately on the continents themselves. Nevertheless, it had not yet occurred to any one to examine our continents with this view: an attempt had indeed been made to account for their origin, it being very evident that they are not so ancient as our globe itself, and that they must have been formed, as we find them, by some physical cause; but the different causes to which they were assigned would have operated so slowly, that the whole series of the historical ages were not sufficient to produce any quantity of the known effect, within a known time. For this reason, therefore, conceiving it to be impossible to limit, by immediate observation, the antiquity of the present state of our globe, no other bounds were set to it than were demanded by systems. Accordingly, this notion of the prodigious antiquity of our continents, which we find peremptorily opposed to the account of Moses, does not proceed from facts; it is brought forward only as an hypothesis necessary to other hypotheses.

11. Let us, however, for one instant admit the opinion of these geologists, that, "we should search in vain in our continents themselves for documents that might serve to determine their age;" then, indeed, if a period of time excessively long, granted by hypothesis to the causes they pretended to have discovered, could have explained the whole scene of geological phenomena, it would have been natural to admit that hypothesis, the time past being without

limits. Wherefore, when I examined these systems in my Letters on the history of the earth and of man, I at first made no objection with regard to time; I dwelt only on the supposed causes; but, when I came to compare in respect to each the effects attributed to it, with what it was to explain, I easily made it evident, that none of them would have been thought of, had the inventors of them been ever so slightly acquainted with geological phenomena; for there is not one of those causes, whatever portion of time may be allowed it, that can account for the most common of these phenomena.

12. Nevertheless, this hypothesis of the immense antiquity of our continents, so gratuitous in itself, and so useless, since it supplies us with no causes competent to explain the phenomena of the earth, is the sole argument that has been opposed (as the evidence of nature) to what Moses has related respecting the renovation of the human race, owing to a great revolution, which, at no very distant era, affected the whole globe; while, on the contrary, after having shown, by refuting the systems of these geologists, how inconsiderate their attack of this article of the public faith has been, I adduced various decisive phenomena, as the evidence of nature, to prove, that our globe must necessarily have undergone that revolution, at the time stated by Moses, since our continents are not, in fact, older than his history represents them to be: which circumstance, considering the magnitude of the event, is of itself a striking confirmation of this revelation. I have traced out some of these phenomena in my former Letter, and am now, Sir, going to show you, that we may expect a successive multiplication

deluge, and the generations and history of which he connects with the times in which he wrote. But the more important this geological proposition was, the more indispensable was it that it should be proved by observations made immediately on the continents themselves. Nevertheless, it had not yet occurred to any one to examine our continents with this view: an attempt had indeed been made to account for their origin, it being very evident that they are not so ancient as our globe itself, and that they must have been formed, as we find them, by some physical cause; but the different causes to which they were assigned would have operated so slowly, that the whole series of the historical ages were not sufficient to produce any quantity of the known effect, within a known time. For this reason, therefore, conceiving it to be impossible to limit, by immediate observation, the antiquity of the present state of our globe, no other bounds were set to it than were demanded by systems. Accordingly, this notion of the prodigious antiquity of our continents, which we find peremptorily opposed to the account of Moses, does not proceed from facts; it is brought forward only as an hypothesis necessary to other hypotheses.

11. Let us, however, for one instant a opi-
nion of these geologists, that, "we sho in
vain in our continents themselves for d that
might serve to determine their age;" od,"
a period of time excessively long,
thesis to the causes they pretende
vered, could have explained the
logical phenomena, it woul
admit that hypothesis, th

limits. Wherefore, when I examined these systems in my Letters on the history of the earth and of man, I at first made no objection with regard to time; I dwelt only on the supposed causes; but, when I came to compare in respect to each the effects attributed to it, with what it was to explain, I easily made it evident, that none of them would have been thought of, had the inventors of them been ever so slightly acquainted with geological phenomena; for there is not one of those causes, whatever portion of time may be allowed it, that can account for the most common of these phenomena.

12. Nevertheless, this hypothesis of the immense antiquity of our continents, so gratuitous in itself, and so useless, since it supplies us with no causes competent to explain the phenomena of the earth, is the sole argument that has been opposed (as th[illegible]idence of nature) to what Moses has related r[illegible] the renovation of the human rac[illegible]wing t[illegible] revolution, which, at no very d[illegible] aff[illegible]hole globe; while, on the con[illegible] ha[illegible]n, by refuting the systems of [illegible]gi[illegible] considerate their attack of [illegible] faith has [illegible] adduced [illegible]ena, as the [illegible] of natur[illegible]e mu[illegible] [illegible]

It is these masses, thus overthrown, which rest towards the interior of the chain, against the strata of schists and grey-rock[1], which are more boldly and

[1] The term *grey-rock*, which I have already adopted in my other works, because it was formerly in use, though now seldom employed, leads me to a general remark. There prevails much uncertainty in the nomenclature of many of our strata, because the several shades between them, multiply in proportion to the labour bestowed in distinguishing their species, as well by their external characters, as by their composition. But, in respect to the former, descriptions can seldom supersede the necessity of ocular inspection; and with regard to composition, the products of the chymical analysis of substances very different in their external characters, are so nearly similar, that they afford but a very feeble aid towards the ascertaining of them. These researches are not indeed foreign to the geologist; on the contrary, a profound acquaintance with their results is indispensable, in order to obtain with some degree of certainty the solution of those two important questions:—whence have proceeded the substances of which our mineral strata are composed? And by what kind of cause have successive changes taken place in their nature? But while the lessons of mineralogy are present to his mind, as data from which it is not permitted to depart, the geologist must confine his researches to *general phenomena;* since it is evident that with regard to effects that have formerly been operated on the globe, but are operated no longer, mineralogy, were it much farther advanced than it actually is, could conduct us only to *general causes.*

For this reason I have, in the first place, divided the numerous succession of the different species of strata, observable in the great chains of mountains, into three general classes, the consideration of which is sufficient for the great objects of geology. One of those classes may be designated by *granite,* which constitutes one of its principal parts; it comprises likewise the porphyries, and different species of other strata intermixed with those; it would nevertheless be very difficult, perhaps even impossible, to fix any limits to that class, because it is separated from the following by strata which partake more and more of the nature of the latter: the quartz, feld-

more generally turned up than the former, though to this there are many exceptions. These last are clearly

spath, and mica are observed to diminish, and the clay to increase; and we thus arrive at the class where the primordial schists, or primordial foliated strata prevail, but which are intermixed with compact beds partaking of their substance; and these last it is which I have denominated grey-rock, from the name of grau-wacken, which is applied to it by German miners. In that mass of rock it is, that are found the principal mineral veins, and it is difficult to distinguish in the interior of the mountains the compact beds from the foliated strata, because it is the action of the atmosphere which divides the schists into leaves or plates. This compact stone, which I have called grey-rock, has many varieties, and mineralogists distinguish it by different names; it corresponds with horn-rock, and the trapps; and when fractured, bears most resemblance to basalt and compact lava. But these relations, (or differences) in appearance, hardness, colour, and kind, or proportions of discernible ingredients, are but very remotely connected with general causes, as I shall have occasion to render evident; so that by grey-rock and the contemporaneous schists, I would designate only a great class of strata, which succeeded to that in which the granite and porphyry prevail, and of which the general mass is very well ascertained. It is also known that those two classes of strata are called *primordial*, because they contain no organized bodies; and that to the latter succeeded a third class of strata, consisting of calcareous stone, and containing marine bodies. Such are the three classes of strata to be attended to in the great chains of mountains; and it is under the same general point of view, namely, by comprising distinct masses under certain general characters, that I here consider all our strata;—I have deemed it right to assign my reason for this on first entering upon the subject, in order that they who are more conversant in mineralogy than geology, may be enabled to see, that in submitting myself to the examination of the former, I was to avoid loading with details the statement of its general results, which constitute one class only of the objects, in which the latter is conversant.

[From the above note it would appear that our author already entertained correct notions respecting the series of formations. The

primordial; that is to say, their formation has manifestly preceded the existence of organized beings on our globe, as we find no vestiges whatever of any in them. Lastly, these strata, the sections of which appear almost every where on the summits of the eminences to which they belong, lean in this situation against those of granite or other rocks of its class, which occupy the very centre of those chains. In the centre itself the greatest confusion prevails; and among the ruinous masses which rise above the debris of the strata, in some of which masses these last have more or less preserved a horizontal position, a number of others rise in the form of obelisks, where the strata are almost vertical.

24. The descriptions of these mountains may be studied with advantage in the memoirs of M. Pallas on Siberia, of M. Patrin on Daouria, of M. de Dolomieu on the Tyrol, of M. Ramond de Charboniere on the Pyrenees; or in the coloured prints of M. de Mechel; but chiefly in the Voyages dans les Alpes of M. de Saussure, a classical work in geology, from the number of well-described facts it contains, and its many valuable and fundamental remarks. Among others, we are indebted to this last naturalist, for reducing to order that chaos of mineral substances which we find in the great chains of mountains, where all who are disposed to consider them with attention,

grey-wacke constitutes a part of the transition rocks, of which he forms the second class of his primary rocks. His division of rocks into three classes corresponds to the present classes denominated, 1. Primitive rocks—2. Transition or intermediate rocks—3. Secondary rocks, consisting chiefly of calcareous formations. In some instances transition rocks contain organized bodies.] Ed.

may now readily discover, that the different strata which are there to be seen resting one against another, must have been formed one above another; as is evident with regard to the calcareous masses enclosing marine bodies, where the strata are at present found resting against each other, exactly as they all in common rest against the primordial substances: and it is no less evident that it is owing to disruptions of the entire mass of the strata that happened in those places which now form the centre of these chains, in consequence of the lateral subsidences of the masses thus divided, that those strata which were originally inferior, are found the most elevated, and turned up towards those centres, in the same manner in which the strata that were then uppermost are now overthrown on the outside.

25. M. de Saussure likewise sets out with the marine bodies, as being our first guides in geology; by them, particularly, he demonstrates the catastrophes to which those masses of various substances which compose our great chains of mountains, have been subjected since their formation. The juxta-position of the layers of all these substances, leaves us no room to suppose that one could have changed its situation without the other. Now, those of our strata that contain marine bodies, which we now find so considerably inclined, must necessarily have been at first produced in a situation nearly horizontal; consequently, the strata that contain no marine bodies, called primordial, to which they are so near, which are inclined together with them, and against which they rest, must at that period have been horizontal too, and beneath them. However, this proof, evident as it might be,

was not the first that struck M. de Saussure; habit produced at first in him the same inattention in this respect as had prevailed among all other geologists. Some new phenomenon was requisite to lead him to reflect; and it was in the very bosom of these primitive masses that he found it, where he discovered strata of breccia, or pudding-stone, turned up and fractured towards the summit, like those of the schists and granites which invest them; a phenomenon of which many examples are to be met with. Now such beds must necessarily have been formed in a situation almost horizontal; for since they have enveloped the fragments of other stones, they must evidently have been at one time soft; and we cannot suppose that these strata which lie quite as parallel to each other as they do in all the other classes, have been deposited in the midst of a liquid, in a situation nearly vertical. No doubt, therefore, can remain respecting the original position of all the strata that compose the mass of these mountains; all of them, beginning from the granite, have been deposited in a horizontal situation; and consequently, their series, proceeding outwards from the centre of the chains, indicates a succession of chymical precipitations that took place in the liquid which at one time covered our whole globe.

26. I confine myself to this example drawn from our principal chains of mountains, since the mineral strata which had their origin subsequently to those convulsions, of which the above stupendous monuments remain, accumulated on a base already fractured, and which often underwent partial catastrophes; whence resulted local changes in the liquid itself, and consequently precipitations of various kinds; so that

the succession of these strata has little uniformity. I will point out the principal circumstances relating to these in my next Letter; but as my present purpose was solely to prove that the whole mass of our continents is composed of strata, formed successively from a liquid, these details are not necessary here; since there never has been any doubt respecting the stratification of these substances which we call secondary, or sometimes tertiary, by which the primordial substances have been so covered, that had it not been for the convulsions, which have brought them outwards, either in great masses, as in certain chains of mountains and hills, or in fragments dispersed almost every where over the surface of the soil, we should have known nothing of their existence.

27. I have been obliged, both in my former Letter and in this, to mention that great character of our geological monuments, namely, the confusion that prevails through all the classes of our mineral strata, as a fact; (though I could not yet speak of its cause) for that fact was necessary to the proof of this proposition: "that the whole mass of substances that forms what we know of our continents, is composed of a succession of strata, of which those of granite and of other similar kinds were formed first; and, therefore, must be every where beneath all the other strata[1]." I

[1] The following modification of the author's opinion respecting the regular succession of different kinds of precipitations, occurs in "Travels in England," (1811) vol. III. p. 246. "Although, in a great many parts of the bed of the ancient sea, the granitic strata were covered with schists, grey-wacke, or gneiss, and the latter subsequently with calcareous and sandy strata, (as is the case around the Alps and many mountains in Germany) yet, in my Letters to Prof. Blumen-

shall not for the present dwell on the catastrophes which the strata have undergone, but proceed to consider what the succession itself of the strata exhibits, respecting their origin.

28. When, in my former Letter, I pointed out this surprising structure of our continents, which now present only a heap of ruins, I observed, that we could never form any just idea of this confused assemblage of materials so different in their species, without having discovered how they were produced; and I think I have now shown, "that they have been deposited in the very places where we find them, from a liquid which formerly covered the whole globe; and that they gradually accumulated at the bottom of this liquid, in successive strata, following the insensible inflexions of their base." But how did these operations first commence? By the intervention of what cause were they determined at a certain period? Those who were in the habit of thinking that we had no better guide than imagination in the investigation of events so remote, did not foresee that observation and experience might, in time, lead to the determination of the only cause which could have produced all the phenomena we observe on our globe.

29. We know, then, that setting out from the formation of the strata of granite, a succession of different genera and species of mineral strata has accumulated at the bottom of some liquid in times past;

bach, I had too much generalized this succession of different kinds of precipitations; for in several parts of Europe and Asia there are large spaces in which the granite forms the surface, covered only by loose soils of various kinds, and sometimes even without any covering."

that at the end of a certain period this liquid was peopled with animals, which, in like manner, successively varied in their species; and that the exuviæ of these divers animals have remained imbedded in many of these strata; the last of which, are those of sand and other unconnected substances which we find at the surface of the greater part of our continents. We have also ascertained, that from time to time, these strata, already formed and indurated, have undergone great convulsions, during which they have, in many places, sunk down, leaving only certain eminences, (our present mountains) where such disruptions happened; and we may conclude with certainty, from a number of phenomena, that it was owing to one of these convulsions (the last of which we find traces) that our continents began to exist as dry land.

30. Here then is an uninterrupted series of operations, beginning with the production of granite. If then the formation of this substance took place at a distance of time indefinitely great, all that was necessarily consequent to it, would also have been terminated at an indefinite period. But when our present continents first appeared, they were covered with the huge ruins of the several stony strata, and particularly of granite, the shattered faces of which being exposed to the action of the atmosphere, would in time crumble down, and be reduced to heaps of rubbish. In fact, this operation then began; but it moreover continues, and is far from being near its end. Consequently, the formation of the strata of granite, whence this succession of operations, the monuments of which we find on our globe, commenced, becomes a fixed epoch, which, however remote, is at least at a finite distance

of time; that is to say, which does not reach to the "first origin of things," an expression we sometimes make use of, without being able to attach to it any sense intelligible to man. This is clearly pointed out by facts; and I am now about to show, that physical science furnishes us with means of ascending by the same road through the whole chain of causes.

31. There naturally occurs a previous question upon this subject, which it particularly belongs to chymistry to explain. Since the formation of the strata of granite was the first of the distinct operations that took place on our globe, of which we discover any traces, and since this must have been a chymical operation, —what was that cause, which not having existed previously to this epoch, but happening to exist then, was of efficacy to determine this first operation, and probably all that followed? The instant this question presents itself forcibly to the mind of the chymical geologist, setting aside all subordinate and accessory causes, he soon discovers one indispensable cause, namely, *liquidity*. In fact, to mix together in impalpable powders ingredients, disposed to unite or decompose each other by their affinities, would plainly be altogether fruitless: without liquidity, no effect would ensue; but as soon as this should be produced, the affinities beginning to operate, the necessary results would successively take place. I have already explained the cause of this in my other works, and I bring it forward here as an allowed fact. Thus, then, those ingredients, through whose several combinations, not only all our mineral strata with their various modifications, but the atmosphere itself, and the great body of our present sea, (in a word, all that we ob-

serve in the whole globe) have been produced, might have remained mingled together to eternity, without ever changing their state, had not liquidity been introduced. But as soon as this happened, all the chymical combinations, of which these several ingredients were susceptible, must have instantly commenced, and have continued as long as the combinations, that had already taken place, were capable of determining new ones; and as the several products were susceptible of any new state or modification. We may therefore assuredly set out with this fundamental proposition, "that the precise epoch when all the operations, the monuments of which remain to us, first began to take place, is characterised by this immediate chymical circumstance, that then liquidity was first introduced among the several substances of which its mass was composed; and that this epoch is at a finite distance of time."

32. This important conclusion, drawn from the phenomena I have traced out, which afterwards serves as a foundation for a natural history of the earth, is deducible also from a great fact, which at first seems to be independent of these phenomena; but which is nevertheless connected with them through the same causes. The spherical form of the earth had long ago led to the opinion that its mass had once been in a liquid state, at least to a certain depth; and Newton, calculating upon this supposition, in combination with the present velocity of the earth's rotation, had found that the diameter of the globe between the poles ought to be to that of the equator, as 229 to 230. Now, in the Transactions of the Royal Society of London, for 1791, there is a memoir by Mr. DALBY, in which,

by a comparison of the several results of the measurements of a degree of the meridian at different latitudes, he finds, that this determination of Newton is confirmed by experiments as fully as could be expected from the latter mode of calculation. Thus then it is ascertained, that our globe has actually been in a liquid state, at least to a certain depth, and that when it became solid in the part which determined its form, the velocity of its rotation was sensibly the same as at present: such is the fact I wished to mention.

33. Now let us examine what we know of the solid portion of the globe, namely, our continents. And first, that portion is entirely composed of strata. We further know, that the substances of these strata must have been separated from a liquid; and we have just seen, that these operations must have commenced as soon as liquidity prevailed on the globe. Now our continents have the same form as the liquid mass from which their several strata were separated, namely, the sea. I here speak only of the general mass of our continents, which from pole to pole, has sensibly the same elevation above the level of the present sea. As for the directions of the planes of the strata considered in detail, they follow no certain rule: all is confused and overthrown, as well in the plains and smaller eminences as in the mountains: but this disorder occasions only irregular zigzags in every direction, on one general base which bears the form of our globe, the larger protuberances of which, namely, our highest mountains, observing no latitude or determined direction, show still more clearly that they proceed from particular causes, independent of the

general form of the globe. We may, therefore, state our first fundamental proposition in more precise terms, by changing it thus: "As soon as the mass of our globe became liquid, and had by such means acquired its present form, the mineral strata began to be formed on some solid nucleus," of which I do not at present design to speak.

34. We are not confined by any limits, in such retrospective inquiries into the causes of the phenomena of the earth, till we get beyond what general physics can unfold to us. Thus, we may inquire further, what was the cause, which, not existing before that epoch, began then to produce liquidity among the ingredients of which the mass of the earth was composed? And here again physical science readily suggests to us another indispensable cause. Liquidity is an effect of *fire*; no liquid body assumes this state, except through the combination of a certain quantity of fire with its constituent molecules; and this combination always takes place, in every liquefiable substance, at a certain fixed temperature; so that all liquefiable substances would for ever continue in the state of solid molecules, concrete or uncombined, were they not to be penetrated by that quantity of fire which is necessary to their liquefaction; but as soon as sufficient fire is introduced, they combine with it, and liquidity ensues.

35. In order to apply this physical principle to geology, we must further determine what temperature was necessary for the production of liquidity in the ingredients, of which the mass of the earth consisted; and this we are now enabled to do, by the increase of our geological knowledge, which has banished all ideas

of the earth having ever been fused like glass or metallic substances, except in the case of volcanos. All enlightened geologists agree, that our mineral strata have been produced from a liquid simply aqueous; consequently our fundamental proposition being thus further determined, may now run thus: "That the epoch at which all the operations, the monuments of which remain on our globe, commenced, was, that when its mass was first penetrated by a sufficient quantity of fire, to produce liquidity in the substance of water, and to give to the liquid then formed (containing the elements of all other known substances) the temperature necessary for their chymical combinations."

36. Here then is a distinct epoch, which we cannot refuse to admit as a fixed point within the earth's duration, and which indisputably marks the origin of all the phenomena we there observe. But whence proceeded the fire requisite to produce this great change in a mass of substances, till then incapable of any chymical action on each other? Were this the term beyond which our knowledge could not conduct us, we should be obliged to pause, and content ourselves to descend from thence, to the explanation of the known phenomena; for the certainty of this first action of fire is altogether independent of the knowledge of its source; and we must at last stop somewhere in this scale of causes. But neither geology nor physics abandon us yet; nay even, by the phenomena that the one presents to our observation, and the other stands ready to explain, they rather invite us to further inquiries. This demands some preliminary explanations.

37. Previously to the discoveries that have been made in modern times, relative to the chymical effects of light, some mathematical naturalists disputed its existence, and even that of fire, as particular fluids. They had imagined that the phenomena of light and heat, were only modifications of the substances themselves, which manifested them; certain vibrations of their molecules transmitted through a medium, as in the case of sounds. They applied the mathematics to this hypothesis, in order to explain some particular phenomena; and as every thing that appears to be deduced from mathematical theorems, easily seduces those who do not apply themselves to examine into what is considered as data, this theory, which effectually barred the road to the most important physical researches, met with many supporters. But chymistry and meteorology have now come in to terminate this controversy; and there are at present very few philosophers who do not agree, that lucidity and heat are the effects of two fluids, namely, light and fire, which produce these particular phenomena whenever they are at liberty; but which, at the same time, possess many other chymical properties, whereby they enter into combinations, in which they cease to produce those effects, till again set at liberty. It is in a great measure owing to these discoveries, that natural knowledge has proceeded so rapidly in our age, and the present era will probably be as celebrated in the history of science as those in which Pascal demonstrated the pressure of the air on bodies, and Newton discovered the principle of gravity.

38. We cannot make one discovery in chymistry that may not tend to the advancement of geology;

for, setting aside the causes of the general phenomena, (namely, gravity, cohesion, expansibility, and the affinities, considered abstractedly) all the effects we see produced on the earth, have been, and still are, the results of chymical combinations. Now among the phenomena, properly geological, there is one of great importance which I have not yet mentioned, but which deserves a most attentive examination. It is that of *light*, which manifests itself in several of the modifications of mineral substances.

39. From the first cultivation of chymistry, as a science, one of its main objects was the analysis of bodies; that is to say, the investigation of their component principles: a class of experiments and observations, which had produced a number of useful discoveries, but which had tended but little to advance physical science itself; because the first chymists contented themselves with the discovery of the fixed products only, which, by themselves, scarce give us any insight into the origin of natural bodies. Our progress in this respect has been much accelerated in the present age, since chymists have begun to examine attentively the volatile products, or in other words, the expansible fluids: but this would still have been doing little, had not our advances in the other branches of natural knowledge led them to the discovery, that the phenomena of heat, manifested in several of their operations, proceeded from a particular substance, susceptible of chymical affinities, namely, *fire*, the immediate cause of heat. Here then is a substance of the highest importance in the composition of bodies; which, nevertheless, escaped our notice as long as we were used to estimate and ex-

press the amount of their products by their weight only. Now, is it possible to suppose that we have hereby discovered all the imponderable substances that enter into the composition of natural bodies, while we continue unable to recompose any one of these bodies? Above all, ought we to neglect the phenomena of light, while every thing assures us that light is also a chymical substance? This negligence is no longer to be apprehended from our chymical philosophers, to whom these advantages in natural knowledge have already sufficiently shown, that very great chymical effects may be produced by imponderable substances. Thus, from the phosphoric phenomena of certain mineral bodies, we have been led to acknowledge, that light has entered as an ingredient into their composition; and consequently that its influence in the phenomena of geology must have commenced from the first production of a liquid, containing all the ingredients of those substances, and in which they were formed.

40. Lastly, if we examine by the light which has been thrown upon this department of knowledge, the relations that subsist between these two primary imponderable fluids, whose existence is now established beyond a doubt, we shall find in them those of which chymistry furnishes so many instances, in substances entering into the composition one of the other. Light frequently does not act sensibly, otherwise than as the cause of lucidity; and fire in the same way, only as the cause of heat; but at other times, fire, in producing heat, produces also in the end its luminous effects; and in some circumstances light, in making visible the objects by its reflection, contributes to the

increase of heat. Such phenomena, many analogous to which are supplied by chymistry, always indicate that one of the two substances, the effects of which are compared, contains the other which causes it, in this union, to enjoy some distinctive property; but which, nevertheless, is susceptible, in certain circumstances, of decomposition, thereby leaving the other substance at liberty to exercise its own peculiar property. Some naturalists, and among others, M.M. Senébier and Pictet, proceeding from these analogies, had already remarked, that the conformity between the effects of light and fire, in certain determinate circumstances, though the effects peculiar to those two fluids are so very different, in their most common phenomena, could arise only from one of the following two causes; either that light contained fire, which in certain circumstances disengaged itself; or that fire contained light, which in certain cases produced it, and from which it disengaged itself in others. This is not the place to discuss that question. I have done so in my Idées sur la Météorologie, and in some Letters addressed to M. de la Métherie, published in his Journal de Physique, where I have assigned my reasons for adopting the last of the propositions of this dilemma, to which the whole of terrestrial physics leads us. Here then we have a proposition, respecting which no further doubt can be entertained: namely, that fire cannot exist without light. Finally, embracing all the modifications of known expansive fluids, and all the luminous phenomena of mineral, vegetable, and animal substances, we cannot avoid perceiving, that the office of rendering objects visible, important as it certainly is to us, is yet the least so

of all those which light performs among the physical operations, to which the organized beings of our globe owe their preservation; that either alone, or by its combination which produces fire, it must have entered into the composition of most known substances on our globe, and in our atmosphere, and that without it nothing of what we observe on our globe would have taken place.

41. Here then I am content to stop in my enquiries into this chain of causes, whence all the known phenomena of our globe have proceeded, because I perceive nothing in physical science that can conduct us beyond that limit. The link immediately more remote ought be the source of that light, which, by its combination with the other elements, points out to us, with such precision, a certain original epoch in the history of the earth, and physical enquiries do not appear to me capable of ever furnishing the least probable conjecture on this head. But this natural boundary, at which I feel compelled to stop, occasions neither obscurity nor confusion in the subsequent phenomena; all of which, setting out thence, proceed regularly from known physical causes; and it is even from their connection with that first link discoverable by physics which I have been tracing, that I conclude at length—" That nothing of all that we see on the globe, could begin to be operated, without the union of a certain quantity of light to all the other elements of which it was at first composed; elements which, without it, would have exercised no chymical action on each other; and that accordingly all the known geological phenomena date their origin from the time of this union."

I have now, Sir, completed the first part of the task I imposed on myself, that of pursuing on paper the same analytical method I had observed in our conversations, in order to serve as an introduction to an abridgment of the Geological Letters which I have addressed to M. de la Métherie, in his Journal de Physique; though directing my course in a manner more precise and conformable to the object of these Letters, namely, that of demonstrating the agreement of nature with faith in the earliest of the divine revelations. In pursuance of this plan, I have hitherto given an exposition of the true characters of geological phenomena, and the means which physical science supplies for ascending by them to an epoch in the earliest periods of the earth, when nothing of all that we observe there had as yet been produced. From that epoch therefore I shall set out in the following Letters, in order to trace from thence the principal events which have taken place on our globe; and I shall do so from monuments more intelligible than are the greater part of those of the ancient empires on the continents which we inhabit.

I have the honour to be, &c.

LETTER III.

On the History of the Earth, from the origin of what is now observed upon it, down to the production of the strata of Sand-stone.

Windsor, September 18, 1793.

SIR,

I CONCLUDED my last Letter with this proposition, deduced from the principal geological phenomena, "that nothing of all that we see on our globe could have been operated, had not *light* been added to, and introduced among the other elements of which its mass consisted; but that as soon as this happened, the chymical operations, which have produced the whole of the phenomena of geology, necessarily began." Thus then it is that nature herself already bears testimony to that great command of the Almighty, at the commencement of the Mosaic narrative:—"Let there be light[1]!"

[1] The following passage, (here quoted by the author in a note, of which the substance will be given) is extracted from the "Mémoire sur les Roches," &c. in the "Journal de Physique," by M. de Do-

1. The operations that took place subsequently to this great epoch, until the creation of man, recited in the first chapter of Genesis, are there divided into six periods, called, in our translations, "days;" and upon the common interpretation of this word it is, that unbelievers have founded their most specious objections against Revelation. For with a slight knowledge of geology, it was easy to oppose many phenomena to a succession of such events as would have taken up only six of our days of twenty-four hours. But it is evident, from the text itself, that this interpretation is erroneous;—for, first, our days of twenty-four hours are measured by the revolutions of the earth on its

lomieu, whom he considered as the naturalist the most deeply versed in terrestrial physics, and whose views on the general principles of chymistry, and on important points in geology were conformable to his own:—"With M. de Luc, therefore, I shall say, that there was an epoch at which an essential change must have happened in our globe, since from such a change has proceeded all that we observe, which had not been produced before." In regard to an objection which M. Dolomieu afterwards makes, viz. that the simple liquidity of water would be insufficient to account for the commencement of the operations, unless that substance should acquire a principle of activity which does not essentially belong to it, our author states his belief that M. Dolomieu will find in these Letters sufficient reasons for believing that liquidity having once been produced in the mass of elements constituting the globe, by the sole introduction of light, as a new chymical ingredient, nothing was wanting for the commencement of the operation; undertaking to show, in a future work, that at the period when water acquired liquidity, it also acquired a principle of activity, by combining with other elements.

De Luc, however, did not consider water, even after it has acquired a principle of activity, as the only dissolving agent; he maintained that all the elements were reciprocally solvents one of another. Ed.

axis, opposed to the sun as a luminous body; but the sun is not mentioned in this relation till the fourth of the days in question; consequently, they are not days of twenty-four hours, but certain portions of time of an indeterminate length. And it is now long since biblical critics and interpreters have observed, that the same word as that in the text is employed in this sense in other places in the book of Genesis, where the word *morning* is put for the beginning, and the word *evening* for the end of some period. And this is the only way of understanding the description given of each of these days: "And the evening and the morning were the first day;" and so of all the others: for as the interval between the evening and morning constitutes only a portion of a day of twenty-four hours, and not one of those days, while the beginning and end of a period render it complete, we clearly see by that difference what must be here the meaning of these words employed in the two senses by Moses. This is the only remark I had to make upon the text, before I entered on the task of showing the astonishing conformity of our geological monuments with the whole of this sublime history, in its precise order; and that the attentive reader may notice this agreement (though henceforward I shall treat this subject only as it relates to natural history and physics) I shall divide into SIX PERIODS, the series of physical operations which have taken place upon our globe, from the existence of light, to the appearance of *man* on our first continents.

FIRST PERIOD.

2. I have proved in my former Letter, that pre-

viously to the addition of light to the other elements of which the mass of the earth was composed, every thing was in a state of relative rest; because no affinity could yet operate; we can, therefore, consider this primitive mass as composed only of various elements, without any union among themselves. Now this assemblage of which the earth at first consisted, as well as that of the masses of all the great bodies which compose the sensible universe, the commencement of which is expressed in the first words of Genesis, "In the beginning God created the heaven and the earth," cannot be better explained by physical causes, than by the addition of light to all those bodies, when God said, "Let there be light!" All those who have a lively perception of the sublime, have been struck by the grandeur of that introduction to Genesis; but their homage is but faint, in comparison with that rendered to it by the advances made in physical science.

3. Theorists, who in our age have continued to seek in matter qualities to which might be ascribed the formation of the great bodies in space, no longer venturing to uphold the atoms of Epicurus, conceived they could substitute for it universal gravity, namely that tendency of the particles of matter towards each other, to which the phenomena of the fall of bodies on our globe, and the persistence of the planets to move in their orbits according to certain laws are ultimately resolvable, a tendency which (in opposition to the express intention of the great man to whom we owe that discovery) they have converted into an essential quality of matter. I shall not dwell upon this preposterous opinion, which ascribes to the particles of matter the power of acting where they are not; an

opinion which is more indefensible than the occult qualities of the ancients: I shall confine myself to showing the total incompetency of the hypothesis, to explain the phenomenon to which it refers. If these speculators had consulted the astronomers, to whom we must apply in order to learn the degree of force of this tendency, considered in each particle of matter, they would have taught them that it is incomparably too feeble to occasion two particles, moving and meeting together in space, to remain united to each other; because each would continue its own course, only with some deviation. Gravity, indeed, retains particles near large bodies, but it is by their tendency towards the whole mass; accordingly, it would be necessary, that this mass should previously exist as such, for the particles to be retained; and gravity alone is incapable of producing it. The cohesion and the affinities, observed in the moon as well as upon our globe, and which, doubtless, exist in all the other large bodies, are vaguely included in this hypothesis; but these are evidently phenomena resulting from the previous composition of those bodies, after the addition of light: for all known bodies, both in the moon and upon the earth, in which we find a coherence of their particles, as well as all similar bodies of which we witness the formation, or which we produce ourselves, are chymical productions which have required, and still require the presence of fire, in order to produce liquidity or the volatilization of the masses, under the indispensable influence of gravitation towards a large body. Now the large bodies could not have been produced by that which could exist only after their production: these are general and invariable princi-

ples in physics, deduced from universal observation and experience; every hypothesis that is not grounded upon them is wholly chimerical. Agreeably to these principles, therefore, we are obliged to acknowledge, that the formation of the great bodies in space, could not have proceeded from any known physical cause; and we are also led to conclude that before the addition of light to those masses, the epoch of which is the beginning of chymical operations in the universe, they could be composed only of disunited elements, which in the sequel I shall designate by the name of *pulvicules*.

4. The light first introduced into the mass of the earth did not proceed from any luminous body like the sun; for, besides that this would be only removing the difficulty further, in respect to the origin of light, that substance not being productive of heat, but as it unites itself with the element of fire, if the rays of the sun had fallen on this mass, they would have been able only to produce fire at the exterior part, in uniting with whatever they had there found of its elements; after which their calorific effect would become for ever null. This is their present effect; which, with respect to heat, is confined to repairing the fire which is decomposed, as I shall in the sequel explain. Accordingly, the first addition of light to the other elements of the earth, must have been a penetration of this substance extending through the whole mass; and this penetration, both in regard to the earth, and the other great bodies in space, cannot be assigned to any known physical cause.

5. I have already, in my former Letter, shown the immediate effects of this addition with respect to the

earth, namely, the production of fire by the union of light with a particular element; the liquefaction of water by the union of fire with the element of this last, and different chymical combinations of light with other elements. It is, therefore, from this point, I shall trace out the series of operations which thenceforth took place upon the globe, directing my course by geological monuments, and by the general causes manifested by physical science.

6. The element of water existed only down to a certain depth in the mass of the earth, but there it was in great abundance: so that immediately after its liquefaction, a confused mixture of all the elements was produced, forming a heavy, turbid liquid, from which, by chymical operations, all the substances we see on our globe and in the atmosphere, were successively separated. But before we come to these operations, we must apply ourselves to consider the form which the mass of the earth assumed immediately after the liquefaction of water.

7. I have proved in my former Letter, that before the production of our mineral strata, and, therefore, before the earth had any solid parts, it had sensibly the same form as it has at present: of course, it had the same rotatory motion. Now this also manifests a CAUSE independent of matter; for it is impossible that a liquid mass, or one composed of unconnected pulvicules, suspended in space, could have acquired this motion from a shock. A body which should have impinged with a force sufficient to produce this effect upon a solid mass by striking it laterally, meeting with this inadherent mass, would have taken and carried away (without any resistance but that arising from

the *vis inertiæ* and a slight degree of friction) that portion which it should have encountered in its passage; for the tendency of this portion towards the rest of the mass, through the influence of gravity, would have been instantaneously compensated by its tendency towards the impinging body, to which it would have remained united; and the remainder of the first mass would have then recovered a spherical form, with some progressive motion, in the direction of that body, towards which gravity would at first have impelled that remaining mass, while it was near; but there would have been no rotatory motion in that mass (at least not sensibly) because all the lesser partial motions excited by friction would have been confounded and reduced to one, by the return of the mass to its spherical form. Accordingly, the earth, the planets, the sun, and all the stars, in which Dr. Herschel is continually discovering rotatory motion, and of considerable velocity in some, could not have received that motion by any known physical cause.

8. Those who think that motion is essential to matter (the favourite atheistical hypothesis) have endeavoured to explain the various motions of the planets, distinct from those which the cause of gravity continually impresses upon them, by that meeting and union of particles to which they ascribe the formation of the great bodies in space; assuming that the motions of those bodies, as well that of rotation as their progressive motion, are the mean results of the individual tendencies of the particles to follow their own proper motion. I have already shown that gravity is a tendency incomparably too feeble to cause the particles of matter to cohere; but I am willing here to

grant it this power, and to confine my observations to motion.

9. Every man of common sense will agree, and the atheists themselves must allow, that this hypothesis of essential motion, is nothing more than an expression without meaning, till it be determined by an application to some precise phenomenon. Let us then apply it to the rotatory motion of the earth—a motion which we must be able to explain by this hypothesis, if we are to attribute it to a physical cause; since we have just seen, that it cannot be considered as the effect of a shock. The hypothesis, that motion is essential to the particles of matter, necessarily implies an invariable tendency of each particle to move with a certain velocity towards some point in space, which shall be opposite to one of its faces. It will, I say, move invariably towards such point to eternity, with a determinate velocity, if left at liberty; this is what must be understood by an *essential quality*. If two of these particles of equal mass and velocity, meet centrically as they move in opposite directions and in the same line, they will mutually stop each other: however, (according to the hypothesis) their motion will not be destroyed; it will remain *in nisu*, and would recommence if those particles came to be separated; but if they meet obliquely, and unite, they will together follow a middle course between their two particular directions, which will make them whirl. This is the whole system; whence it results that in the great bodies of space which have a certain rotatory motion, no one particle has lost its own motion; and that thus, for instance, it is the combination of all those motions, owing to the coherence of the parti-

cles, which has produced the rotatory motion of the earth, as well as its progressive motion.

10. Here then, as in all cases where we shall apply that hypothesis to a precise phenomenon, its falsity becomes palpable; and first, the earth having the spheroidal form which its rotatory motion would impress on a liquid mass, it must have been liquid, at least to a sufficient depth, when it first acquired this form. Now it is contrary to physics, that the particular motions of the particles can combine in a liquid so as to create a whirling motion of the whole mass; since one of the properties of liquids is the slight coherence of their molecules: we ought, therefore, to suppose, contrary to all probability, and in opposition to what we know of the chymical operations on our globe, which required liquidity, that by the aggregation of all these particles in motion, a solid spheroid was formed, precisely similar to what would have resulted from the same rotatory motion that had been impressed on a same liquid mass; and thus it would be, that the solid mass of the earth would be turning on its axis, with its mountains and their craggy summits. But in that case, what would become of any fragment broken off from one of these rocks? To examine this matter, let us go back to the hypothesis. —Each particle retains necessarily its proper motion, that is to say, a certain velocity, following a certain direction relative to one of its sides: this is essential to it, and operates incessantly, even *in nisu*, where the motions are counterbalanced. The fragment then will also be composed of a certain number of these particles, adhering to each other, preserving their properties of a certain velocity and direction, and producing

in common a velocity and direction of the smaller separated mass; this mass will consequently acquire such proper motion, modified only by gravity, from the moment it shall be detached from the rock. But will this motion be the same as that of the mass of the earth? Will the motions of all the fragments that have hitherto been detached from rocks, as well as of those which are incessantly breaking off, accidentally coincide with each other, and with that of the principal mass? It would be absurd to suppose it. Now all the fragments that have been detached, and are daily detached from rocks, have followed, and do follow, during their fall, all the motions of the surface of the earth, at the latitude in which they happen to be. It therefore follows that the particles of matter have no peculiar motion of their own, or essential to them; all the particles which compose the earth, received at first, in common, the impression of the motions which the mass preserves, excepting some changes produced in the motion of the molecules, which, owing to some particular cause, change their parallel or distance with respect to the centre: the small masses that are detached from it preserve these motions, unless some new cause should impress upon them different ones from those, or contrary to their tendency towards the mass; and all naturalists—atheists themselves when they are willing to be considered as such—are so intimately convinced of this truth, that whenever they observe in masses or particles, motions different from those of the earth (which, according to immediate perception, constitute the rest of bodies upon it) or from what gravity requires, they

seek the cause of this phenomenon in some new event produced by terrestrial causes.

11. It is only from a system of physics, as fanciful as those whence have been deduced so many erroneous theories of the history of the earth, that some speculative men have been led to imagine these *essential qualities* by means of which they have also endeavoured to give us histories of the universe; and these chimerical ideas solely obtain among some men, from their being willing to seek in their own imagination what physics and geology refuse them, and which can be ascribed only to a CAUSE superior to matter. Errors are easily imprinted on the memory by words, and the imagination readily seizes on them: whilst truths, which are facts, with logical deductions from them, exact a great degree of attention to produce their effect on the understanding; and to this is owing the slowness of their progress.

12. In following out this series of facts and their immediate consequences, I have now established, with respect to the first period, from operations of which we find the monuments on our globe, that after the addition of light to the other elements, proceeding from some cause that we cannot trace in physics, a rotatory motion, of which we also find no cause in matter, occasioned this mass (having yet no solid parts) to assume the spheroidal form, which it still retains. A dense liquid occupied at that time the exterior part of that spheroid, to a certain depth, and the rest consisted only of pulvicules without adherence. This is the state of the earth, whence I shall now proceed; and the conformity of the geological monuments, with

what ought to result from the causes now established, will at every step point out their reality[1].

SECOND PERIOD.

13. General chymistry must here be our only guide, as to principles; and it is but lately that it has furnished us with any certain lights in regard to these. Accordingly, all the systems formerly invented respecting the most ancient periods of our globe, have mutually destroyed each other, and vanished like dreams. The first essential step that has been taken towards this object, is the general conclusion, deduced from the whole collection of facts, after a course of long observations, that all the substances that compose our mineral strata, must have proceeded from chymical combinations in an aqueous liquid.—M. de la Métherie was the first that published this general idea, in 1767, mixed up indeed with many errors. M. de Saussure, after more general and precise observations, first conceived the idea, that all the substances which he had generally found composed of strata, have been formed by successive different precipitations from one and the same liquid. Pini has also demonstrated, that these operations must have taken place in an aqueous liquid. At length, M. de Dolomieu, after having acquiesced, in consequence of his own observations in different countries, in the system of M. de Saussure, has added to it this material circumstance, in which I entirely agree with him, from my own observations, and the whole assemblage

[1] For further developments of this part of the subject, see "Journ. de Physique," vol. xxxvii. (part ii.) p. 330, et seq. 1790.—Ed.

of facts; viz. that there is no operation now taking place in the sea, that bears the slightest analogy to those productions of mineral substances in strata, which took place formerly on our globe.

14. It is, I repeat, chiefly our advances in chymistry which have led to this general conclusion, whence at length has resulted a solid base in geology, and which, by furnishing us with sound general principles, have opened the way to new discoveries. I have treated of these principles in several of my Letters in the Journal de Physique; but as one of the most important has also been described by M. de Dolomieu, in his Mémoire sur les Pierres composées et les Roches (in the same Journal, May, 1792), I prefer citing him in his own words:—"In the analysis of stones (he observes) it is of more consequence to distinguish and specify the sort of association that the constituent matters have among themselves, by the intervention of some fluid, or by its subtraction, than it is to ascertain the number and exact proportions of the substances discovered by the analyses. For it is more the particular state of the combination, than the substances themselves, that determines and truly fixes the nature of the compounds. It is thus that the heaviest stones and the lightest are produced by combinations of the same sensible substances; thus also the hardest and most tender; those the least liable to be acted upon by acids, and those most readily affected by them; those that are decomposed the most easily, and those that are the most durable; those on which fire has but a slow effect, and those which may be most rapidly fused. In a word, the stones the most dissimilar in external appearance, are found by ana-

lysis to consist of the same constituent parts; which proves, that chymistry will be but a feeble assistant to lithology, as long as it confines itself to the weighing of the substances we extract, neglecting the most important circumstances, those which have had the greatest influence in their combinations, and which are the cause of a certain stone being really different from another, though the component matters may be nearly similar."

These general remarks are the result of a number of instances cited by M. de Dolomieu, and it is also what every attentive naturalist would conclude, from the singular resemblance there is to be found between the lists of the ingredients that indicate the products of the analyses of very different mineral substances.

15. From these considerations, which had also struck me for a long time, and which I had already alluded to in my "Lettres sur l'Histoire de la Terre," M. Dolomieu and myself first arrived at the same general theory of chymical precipitations, the fundamental principles of which are to be found in our respective Memoirs, in the "Journal de Physique," and of which I will give an abridgment. There are many distinct operations in the formation of sensible solids, produced by chymical precipitation in liquids. The first operation, though the most hidden from our immediate observation, is, nevertheless, that with respect to which physical science supplies us with the most certain principles. It is the transformation of liquid molecules into solid molecules, without any change of temperature. Liquidity is now very well defined in its characteristics, and we know that it de-

pends on the union of fire with the molecules of certain substances, an union which takes place at a fixed temperature in each, and which ends when they are cooled below that temperature. This union must cease, or change its nature, before such molecules cease to be proper for liquidity, and become fit for the production of a solid. As long as no change happens in the nature of the molecules of a liquefiable substance, it is liquid above a certain temperature, and solid below it: but if it happens that there be any addition to, or subtraction from, certain ingredients in the liquid, the effect may be the formation, in greater or less quantity, of molecules, which have no longer the property of forming a liquid at the same temperature, nor even in certain cases at any temperature, unless they undergo some new change. This is what I understand by the formation of solid molecules in a liquid, an operation, the principles of which are very clear in physics. Now the particular affinities which act in this first step of every chymical precipitation, distinguished in the same manner by M. de Dolomieu, are called, in his Memoir, the affinities of composition.

16. Thus then must commence, before we can perceive the change, the precipitations of solids in liquids; and there already molecules are formed, which, with the same ponderable ingredients, such as we at last find them in our analyses, shall, nevertheless, compose very different solids; and when we study the whole of those phenomena together, we are led to think, that the ingredients, the absence or presence of which contributes to determine this first act, are of a nature to escape our immediate observation. These

solid molecules have different forms, as well as different chymical affinities, which act by determined faces; and thus it is that the solids that proceed from them have themselves either certain regular forms, as in crystals, or a certain grain and particular appearances in their fractures, as we find to be the case in all mineral substances. New affinities therefore begin to act; namely, those which the molecules have acquired by their composition, and which act either upon each other, or together with other substances, whether simple, or previously compounded; these are what M. de Dolomieu calls affinities of aggregation. Now although there can be no doubt respecting the distinction of these two acts in the production of sensible solids, we are unable to ascertain if it is in the latter or in the former that those solids acquire the properties by which we see them produce or absorb, during the process of analysation, certain expansible fluids, known indeed in regard to their external properties, but the composition of which is still very obscure, as is rendered more and more evident by the differences of opinion in regard to them. Lastly, the aggregation itself is of two very distinct kinds, proceeding likewise from the nature of the first solid molecules formed in the liquids, although with the same ponderable substances, which will at length appear in our analyses. One kind of these aggregations produces immediately large solids, more or less regular, namely, crystals, or confused crystallizations of different forms; the other kind produces nothing at first but powders or grains, which fall to the bottom of the liquid; and this last kind divides itself also into two sorts, in one of which the little solids remain disunited, and in the other

they have the property of consolidating in large masses, by resting at the bottom of the same liquid. It is this last kind of aggregation which has produced the greater part of our stony mineral strata.

17. Our chymical analyses are, doubtless, much superior to those that were made prior to our age; for now we not only collect all the coercible fluids which disengage themselves from the substances we analyse; but we are able to detect such of these fluids as unite themselves with them; we distinguish these fluids from one another by fixed characters, and we determine, by weight, their quantities; but we are still ignorant, first, at what period of the formation of the analysed solid it had acquired the faculty of producing or absorbing these fluids; secondly, whether the fluids, which disengage themselves during the analysis, really entered into the analysed substance, in the condition we actually observe them at any period of its formation, or whether they are not new productions of the analysis itself; thirdly, whether the fluids that we find to be absorbed during the analysis are actually the same substances, similarly composed, which the original liquid must have parted with, in order to produce the solid we are decomposing; or whether some one of the products of the analysis is not a new compound formed by means of these fluids; fourthly, and lastly, we are not authorized to believe that fire and light, detected during their disengagement or absorption by properties which manifest them to us, are the only incoercible and imponderable substances, which are absorbed or disengaged during our analysis. Every chymical naturalist, who will examine, under all those points of

view, the analyses, which have hitherto been made of mineral substances, either of our strata themselves, or of their different veins, will, doubtless, be convinced that we are absolutely incapable of determining all the ingredients of which these substances are composed, and the manner in which they are combined: and we have a general proof of this incompetency, in the fact that we are unable to recompose almost any of those substances with the ingredients obtained in our analysis.

18. It is, therefore, with great reason, that M. de Dolomieu has observed, in the passage cited above, "that chymistry will be but a feeble assistant to lithology, as long as it is confined only to weighing the substances we extract; and it is on the same ground that, separately, we have both arrived at this conclusion, that, in the present state of things on our globe, we should seek in vain for a menstruum, in which our mineral substances have once been dissolved; since originally there existed simple elements only, while, at present, we see nothing but compounds, excepting light and water [1], the only simple substances

[1] Respecting the nature of water, it will be seen, on referring to the author's work, entitled, "Introduction à la Physique Terrestre par les Fluides Expansibles," vol. i. pp. 185, 188, that he has ascertained that the presence of hydrogen gas is not indicated in the strata of the atmosphere in which *rain* is produced. He hence draws the conclusion that "water is a simple substance, in opposition to the modern system of chymistry, which assumes for its foundation that water is a compound of two substances, termed by the authors of the theory, hydrogen and oxygen." Likewise, in a Memoir inserted in the xxxiiid. vol. of Nicholson's Phil. Journal, and which contains an account of his various meteorological experiments, De Luc has shown that rain is not produced by a moisture actually existing in

we are capable of observing. At first, there was on our globe neither menstruum nor solvend; there

the atmosphere, and that it must therefore proceed from a decomposition of the atmospheric air itself, a fluid *sui generis*, the ponderable part of which must be water. In sections 26, 27, of that Memoir, he, in like manner, adduces reasons for believing that the theory of the composition of water is grounded upon unwarrantable hypotheses; that, from observations made by M. de Saussure and himself in the Alps, the more we ascend in the atmosphere, the drier the air is remarked to be, and that it is, nevertheless, in the upper strata of the air that rain is formed. Consequently, rain is not aqueous vapour condensed, but air itself. Clouds, rain, hail, and thunder, says De Luc, are produced in certain strata of the atmosphere which were clear a moment before, and in which one cubic foot of air did not contain above two grains of water.

In consequence, therefore, of his meteorological observations, the author was led to consider the gases proceeding from the decomposition of the aqueous vapour, by the incandescent tube, only as modifications of the water, by the imponderable fluids constituting those gases; accordingly, the water being the ponderable part, resumes its primitive state, at the time of the disengagement of the principles of the two gases, by the electric fluid. He conceived that the hydrogen and oxygen gases contain separately the water itself, combined with some other substance, different in each of them, and to which their distinctive characters are to be ascribed. See "Journal de Physique," vol. xxxvi. p. 146. Lettre à M. de la Métherie sur la Nature de l'Eau, du Phlogistique, des Acides et des Airs. Janvier, 1790.

In his "Traité Elémentaire sur le Fluide Electrico-galvanique," De Luc has more particularly shown that "every chymical theory, which does not include the atmospherical phenomena, must be arbitrary, and liable, accordingly, to be contradicted by new facts." The following summary of his meteorological theory and its foundations, is given in his Introd. à la Physique Terrestre, &c. vol. ii. p. 438.:—1. Rain, being a mass of water which is detached from some stratum of the atmosphere, can proceed only from a ponderable fluid. 2. Setting aside the small quantity of aqueous vapour which still subsists as such, and the quantity, equally

was formed on it a confused assemblage of elements, in a liquid, of which water was the base; and it is from this first mixture that all substances whatsoever,

small, of some gases, there is no ponderable fluid in the atmosphere, excepting water itself. 3. Aqueous vapour, however, is constantly rising in the atmosphere, and the mass which it adds to the latter, compensates that which it loses by rain. 4. It is therefore necessary, whatever may be the particular manner of it, that in the interval between the ascent of the vapour and the fall of the rain, the vapour should change its form, and be converted into air, and that it should resume its first state when the clouds and rain are forming.

Several able naturalists, among others, Prof. LICHTENBERG, and M. J. A. de Luc, nephew of the author, have concurred with him in his views and conclusions on this interesting subject. "To what purpose is it," asks the professor, "to conceive that we can explain the production of some ounces of water in the mutual decomposition of two gases, if we do not account for the thousands of quintals of that liquid separated from time to time from some stratum of the atmosphere, which, previously to the formation of the clouds, manifested, by the hygrometer, the presence of some grains only in a cubic foot." Such, certainly, remarked the author, is the problem which pneumatic chymistry must resolve. In order, it was said, to judge of the value of the new chymical theory, it must be considered in its relations with the phenomena of nature. If any of those phenomena be in contradiction with the principles on which it is founded, the cautious and attentive philosopher will be distrustful of a doctrine, the application of which to physical science could serve only to multiply error.

"Many experimental philosophers," says De Luc in the Memoir above quoted, "have abandoned the fundamental part of that theory, the composition of water: and, indeed, one of its first inventors, with whom, having seen his experiments, I had acquiesced in his conclusion, and for a time maintained it, I mean Dr. PRIESTLY, caused me himself to abandon it, on account of new chymical results obtained in his experiments, which he opposed to M. BERTHOLLET." It will be perceived from this passage, that Cuvier was in error when asserting in his biographical memoir of Priestly, that "his new writings

on which we at present make our observations and experiments, were successively separated. It is, therefore, only from the general principles which physical science has deduced from chymistry, added to the examination of our globe, and not from the very limited phenomena produced in the actual state of terrestrial substances, that we must trace those first modifications of their elements, the products alone of which remain to us. The general causes, as well as their effects, remain the same under similar circumstances; but by their own operations, circumstances have so materially changed, that we are now able to determine the genera only, and not the species, of their former effects.

19. The first separation of substances which took place in the primordial liquid, served as the preparatory step to many successive effects: a great quantity of solid molecules, which, in their first state, were too heavy to remain suspended in the liquid, and there

did not bring back to his opinion any of those who had abandoned them." Edinb. New Phil. Journ. Vol. III. p. 220.

In three Letters, addressed to M. Fourcroy, inserted in the Journal de Physique, (1791,) De Luc assigns his reasons for considering the modern chymical theory as hypothetical and improbable; and while he admits the fundamental facts, and also the circumstances presented with them by its authors, he further undertakes to show, entering into minute details, that the theoretical consequences deduced from them, must be rejected. See Tom. xxxviii. pp. 460. et seq. xxxix. p. 11. et seq. and p. 117. et seq. See likewise, on the same subject, the nine first, and the fifteenth, of a series of Letters addressed to M. de la Métherie, Journal de Physique, Tom. xxxvi. xxxvii. and xxxviii. (1790 and 1791); and two Dissertations, entitled "Mémoires sur la nouvelle Théorie Chymique," inserted in the "Introduction à la Physique Terrestre par les Fluides Expansibles," Vol. I. Paris, 1803. Ed.

undergo all the transformations of which they were susceptible, subsided and accumulated at the bottom, on the mass of pulvicules, and thus produced a very thick bed, of a sort of slime or mud, mixed with the liquid; while the mass of the remaining liquid still contained all the ponderable substances of our strata, as well as the mass of our present sea, which it far exceeded in quantity. Then commenced a long series of operations, by means of which that liquid underwent successive changes, without the possibility, through any natural cause, of returning to any of its preceding states; without the possibility even of a similar composition being ever renewed in any natural case, or imitated by art; for the causes of the chymical precipitations which took place in it, according to the general laws of affinities, depended upon the primordial state of the terrestrial elements. New combinations were required in this liquid in order successively to separate from it the solid substances which have produced the succession of our different mineral strata; and those changes could be occasioned only by new substances which arose from the bottom; at first, from the mud, afterwards from the pulvicules when they were penetrated by the liquid. And the ascension of those ingredients was followed by the emission of other ingredients of numerous kinds, which, united to fire and light, were disengaged from the liquid under the form of expansible fluids. Thus the formation of the atmosphere proceeded simultaneously with that of the mineral strata; it was composed of a multitude of different kinds of fluids, but its sensibly ponderable mass was formed of water, whether under the state of simple

vapour, or changed into aeriformed fluids by the union of other substances. We shall hereafter have proofs of such a formation of the atmosphere, and of the changes in its state, in proportion as the liquid changed in consequence of new precipitations; but we may already conceive, that the elements, the first general combination of which formed that primordial liquid, having undergone numerous other successive combinations, owing to a first arrangement of circumstances which then only existed,—and being, under these new forms, separated in the different mineral strata, in the water of the present sea, in the interior of the globe and in its atmosphere, could no more combine to produce a state similar to the first, without the express will of the SUPREME BEING, who ordained their first arrangement. In vain, therefore, should we seek to determine the specific operations which have brought the globe to its present state; but the operations of general causes are sufficiently well marked.

20. The first result of this series of combinations, was the simultaneous precipitation of the different crystals of granite, as well as that of various substances, which, in our analysis, yield nearly the same ingredients, and are intermingled with the strata of granite. These first precipitations, as well as all that followed, were subject to suspensions and renewals; for, after the separation of a certain quantity of solid molecules, at the upper part of the liquid, occasioned by the disengagement of the expansible fluids, it required some time for this part of the liquid to recover the same state, by new ingredients ascending from the bottom. It is owing to these interruptions (often

accompanied with some local changes in the liquid) that we frequently find such sensible differences in the size, colour, and proportion, of the different crystals in strata of granite, immediately incumbent on each other; that even different kinds of crystals are found in them, and that the granite strata are sometimes separated by other strata composed of one or two of the substances common to granite, with other variations in the mode of consolidation.

21. These first precipitations formed a very thick crust, entirely surrounding the globe, a circumstance discoverable from the great chains of mountains, where portions of that crust have been thrown up by catastrophes, the cause of which will be hereafter determined. We find no vestige of organized bodies in these strata; none, therefore, existed in the liquid at the time it thus covered the globe; and it was already surrounded by a thick atmosphere, composed of a multitude of substances, but the principal mass of which was water[1].

THIRD PERIOD.

22. After the liquid had parted with those substances, of which the strata of granite and others analogous to them were formed, new kinds of expansible fluids were disengaged from it; whence resulted new combinations of solid molecules, followed by precipitations, very different from the former; these are what produced the gneiss, the wakkes or grey-rocks, the

[1] See further on this subject, Journ. de Physique, Vol. xxxvii. (part ii.) pp. 334—341. Ed.

primordial schists, and the different kinds of other strata we find intermixed with those. It is still, principally, in the great chains of mountains, that we observe these accumulations of strata, and we usually find them resting one against the other, and all of them in common against the granite. Such are the strata, which, (including granite) have for some time been distinguished as primordial, because they contain no vestige of organized bodies.

23. Before I proceed further in the detail of the distinct strata of the different periods which I shall describe, it is necessary more precisely to explain the causes of the variations in their species, as well as the causes of the catastrophes they have undergone. I have just observed that it is principally in the great chains of mountains, and consequently in the present most elevated parts of our globe [1], that we find the strata hitherto enumerated, which, however, were formed the first at the bottom of the liquid; but in their present state they are no longer either regular or horizontal, they are broken and thrown up; and they are considerably above the level of the residue of the liquid in which they have been formed. It is

[1] It has been now ascertained that the primary rocks are to be met with at all levels, down to the sea-coast. They are found at the extremity of Cornwall and Britanny, in the island of Guernsey, in the bay of Dublin, on the coasts of Norway, in the strait of Messina, at the two extremities of the chain of the Pyrenees, and especially towards the Mediterranean, where the granitic belt extends to the sea. They are likewise observable on the coasts of Baffin Bay, on that part of the coast of North America discovered by Captain Franklin, at the Cape of Good Hope, on the coasts of New Holland, and Van Diemen's Land.—Ed.

in the greater sections of these vast eminences, that we can trace the succession of those different strata, which, were it not for the mountains, and some of our hills, would have been absolutely unknown to us; though from other phenomena dependent on the same causes, we may be assured that they exist under every part of our soil; as well as many other species of strata formed subsequently to these. The successive changes in the nature of our strata, and the catastrophes they have undergone, are the two most important geological phenomena we have now to consider; for it is their causes, which, from the formation of the granite to the present state of the earth, have, by their alternate operations, impressed on these all the characters we observe in them. I, therefore, now proceed to state my general views respecting these causes.

24. I have observed, that the first of the strata we are acquainted with, namely, those of granite, and others of the same kind, were deposited on a great accumulation of mud intermingled with a liquid. This liquid gradually filtrated into the mass of pulvicules, and there produced subsidences, as we see to be the case with heaps of sand or other powders when we pour water on them. These pulvicules were of different species; so that the infiltrated liquid produced in them here and there particular combinations, whence proceeded, by degrees also, great and hard masses variously ramified, as we find in a number of disunited or loose substances, such as sand, clay, and many earths and calcareous sands. These consolidated parts, not subsiding at first, formed supports for the crust of the strata, which thus preserved for some time the same level, although by the subsiding of the

pulvicules in their intervals, caverns were formed, in which expansible fluids were collected, produced by the chymical operations within. But when the subsiding of the pulvicules came to extend even under the foundations of the solid masses that formed the partitions of the caverns, these masses themselves sunk down; and the crust losing its support, broke and subsided to a greater or less extent. At every such event, a part of the liquid rushing into the caverns, drove out the expansible fluids confined there; and these, impregnating the liquid above with fresh ingredients, occasioned a change in the chymical combinations; then some new species of expansible fluids disengaging themselves at its surface, produced new kinds of precipitations. These successive absorptions of the liquid which diminished its mass at the exterior, renewed the caverns, by producing new subsidences of the pulvicules; and as the successive infiltrations were of different natures, because the external liquid was more and more deprived by precipitation of its primitive ingredients, there was produced each time some new species of expansible fluid within; and then again new combinations in the liquid above when these fluids ascended thither.

25. Such is a general sketch of the causes that operated in succession for a long time on the globe, internally and externally; they all have their foundations, by general analogy, in known phenomena; and I have already shown, that we have no reason to expect, that the operations of those times can be explained by specific analogies with what we observe in the present state of the earth. These causes then have, *à priori*, all the foundations of which they are

susceptible; and I shall confirm them *à posteriori*, by showing the way in which they explain, in the same general terms, all we observe upon our globe.

26. After various catastrophes happening to the crust, still entirely covered by the liquid, catastrophes during which such of its parts as had been supported by the partitions of the caverns, retained their primitive level, thus forming chains of eminences or mountains, at the bottom of the liquid, an epoch at length arrived, when, in consequence of some very great subsidences of the pulvicules, the foundations of the partitions of the caverns being undermined, at the same time through a great part of the globe, the crust sunk down through the whole of that extent. This is the first general revolution that has left deep vestiges upon our globe; since it is that by which its surface first became divided into sea and dry land; for then the whole of the liquid, which remained at the exterior, gathered on the depressed part, and the rest of the crust remained supported near its first level.

27. It was thus then, that the first continents were formed, which were probably greater than ours; and though since then they have disappeared, we are as well certified of their existence in those times, as we are of that of any ancient city, attested by its remains; this I shall prove in its place. These continents had mountains formed under the waters by the catastrophes that I have just mentioned; and they continued a long time at the same level, partly because they were disburthened of the weight of the liquid, and partly because by these means the liquid could no longer pass immediately into the pulvicules beneath,

to undermine the caverns, and sap the bases of their partitions.

28. Besides those dry lands, forming large continents, other parts of the crust remained at their first level, in that portion of the globe to which the liquid retired, and there formed a number of islands and peninsulas. Vegetation then began to take place on these dry lands; but the vegetables of this period, in which the sun did not yet shine on the earth, were very different from those that exist at present; we know them from their remains found buried in the later mineral strata: it is from them in particular that our beds of coal have proceeded, as I will explain in its proper place.

29. This epoch is still further remarkable, in that the mass of our continents, the foundation of which was already laid by the primordial strata, continued to increase, and underwent the greater part of the catastrophes of which it bears the marks, under the waters of the sea which was then forming. This bottom consisted at first only of the primordial strata, already much broken; principally, because in the depression which the crust underwent, it was arrested on the tops of the walls of the caverns, when after a first subsiding, which occasioned the general falling in of all that portion of the crust, they ceased to sink further into the loose substances; it broke off, at these points, and thus were formed the rudiments of our great chains of mountains. At these points also the strata split in every direction, and their fissures became the nests or seats of our metallic and mineral veins, as I shall explain in time. A great part of the

liquid again introduced itself through the fractures of the crust into the interior of the globe; which circumstance contributed to sink its level relatively to the parts which had not yet sunk; at the same time that it produced in the interior, fresh depressions of the pulvicules and new chymical operations. The expansible fluids, which at that time occupied the caverns, compressed by the subsiding of the crust and liquid, and rushing out with the utmost impetuosity, through the several crevices, detached and carried before them a multitude of fragments, which being scattered over the bottom of the sea, and afterwards mingled with other substances, formed those of our brecciated or pudding-stones, the enclosed pieces of which are primordial stones, and which are covered by new strata. Lastly, the external liquid becoming impregnated with these new fluids, precipitations of a new species were prepared in it, which soon formed a considerable mass of new strata [1].

FOURTH PERIOD.

30. The principal change which distinguishes this period, is that of which the explanation and the proofs require the amplest physical details, as it comprehends all the modifications of fire and light. But these details cannot find a place in a mere abstract, since they alone constitute an essential portion of several of my works; I am, therefore, once more obliged

[1] See "Journal de Physique," Vol. xxxvii. (part ii.) pp. 341—343.

to refer you to them, or at least to my tenth Letter in the Journal de Physique, which contains the physical principles relative to this subject, and shall here confine myself to a simple outline.

31. I have laid it down, as the first foundation of geology, that at the beginning of all the operations, of which we find traces on our globe, the body of the earth received a certain quantity of light, which produced a degree of heat in the whole mass, probably greater than the present temperature. This first degree of heat, however, must necessarily have been diminishing during every operation in which fire and light were concerned, by their entering into chymical combination with other substances, and by the decomposition of fire, in which light escaped. These, also, are the only causes by which the globe could lose heat; for neither fire, nor the substance which in its composition is united to light, can quit it to pass into space, because they are retained near it by gravity. But as soon as fire is chymically combined with other substances, it ceases to produce heat: and this property it loses also when it is decomposed; for then the light, which gave it the power of expansion, becomes free; and the motion of light is so rapid, that it darts into space notwithstanding gravity. Light, therefore, cannot be retained by any globe, be its mass ever so great, except it be chymically combined with some substance; but there is no known substance susceptible of so many various combinations; it is found in almost all terrestrial substances; and all the expansible fluids manifested by meteorology, fluids which were first formed during those operations,

owed to it immediately or mediately by fire, their expansibility.

32. Such then were the causes by which our globe gradually lost a part of its first degree of heat; and which made it necessary to the production of new combinations in the liquid, that it should receive thenceforward a new and constant supply of light at the exterior. Now, here is the epoch at which happened this great change in the causes, which I will first explain, and then proceed to the effects.

33. At the same time that the earth acquired its first supply of light, the sun, which, before that epoch, was yet only as the earth, a distinct mass in space, received an immense proportion of light, by which chymical operations began in like manner to take place; but this mass being in its nature very different from that of the earth, the chymical combinations in it were also very different. Liquidity was, indeed, introduced, as in all the other great bodies of our system, and then also it was that they all assumed the spheroidal form by means of gravity and a rotatory motion; but with regard to the sun, all that we yet know of the chymical operations which took place in its mass, is, that at the end of a certain period it began to be decomposed, as is the case with our phosphoric substances, and that from that time it has continued to throw out light. Such is still the state of the sun; it is an immense phosphoric body, which by successive chymical operations continues to be decomposed. The progress of observation, for which we are chiefly indebted to Dr. Herschell, has moreover taught us that its decomposition constantly renews an atmosphere, from which afterwards light is detached by

a new decomposition, of the nature of those that produce our luminous meteors of different kinds: insomuch that what are called spots of the sun, are parts of that atmosphere, which, either not being yet decomposed, or ceasing for a time to throw out light, enable us, in consequence of their transparency, to perceive the solid and opaque mass of that body, the light of which is not at first disengaged in a liberated state, and in which there is no reason whatever to believe, as it was formerly, that there prevails an intense heat. These observations of Dr. Herschell, the details of which I have learned from him, form an important step in physical astronomy.

34. I have shown above, (§ 4.) that it would have been useless, with respect to the earth, that the sun should have existed, as a luminous body, previously to the operations I have hitherto described; for it would never have been able to communicate heat to that mass, had it shone to eternity: but it is competent to support the heat already existing, for, as I have said above, the substance of fire is preserved to our globe by gravity, and the quantity of that fluid cannot be diminished but by decompositions at the surface, where, in the mean time, the rays of the sun are continually recomposing it; just as fresh supply of fire recomposes the aqueous vapour, which had been decomposed by losing that which had produced it[1]. The rays of the sun also tended to forward many changes on the earth; but this is not the fit place to speak of them; I shall come to them in their course,

[1] See further on this subject, Journal de Physique, Tom. xxxvii. Part II. pp. 343—351. and 441—446.

by following the facts. What we have at present to consider is, the effects produced by the solar rays in the liquid, by penetrating it in consequence of its transparency; effects, which are marked by very distinct monuments, as I shall show under the fifth period.

35. Thus, since the epoch when the sun first began to act upon the earth, the decomposition of fire, as well on its surface, as in its atmosphere, and the disengagement of light by other decompositions, were successively repaired by the rays of this celestial body. There is, nevertheless, some reason to believe that the globe still gradually lost a part of the heat that it then retained; as both fire and light continued to exercise their action in the successive operations that took place during that period of time, as well in the liquid, as beneath the strata. But when all these operations were terminated by the production of our continents, (an epoch from which we are here still far distant) and those which succeeded them on our globe, were reduced to the present alternations, at present subsisting, which follow the vicissitudes of day and night, and of the seasons, the equilibrium of temperature which we observe, was established, and this probably will continue as long as the sun shall continue to throw out the same sensible quantity of light. This is all that a mere abridgement can reasonably contain respecting the modifications of fire and light, and their effects, both past and passing, on our globe: the physical principles of this exposition have their general proofs in the works I have quoted; and the following series of facts will confirm them.

FIFTH PERIOD.

36. After this great change in the terrestrial causes, the precipitations from the liquid varied considerably, and for a long time a new kind took place, which were deposited in strata, upon the primordial schists: these are the strata of greyish hard limestone, the greater part of which are very compact, but which are also sometimes laminated, and which we see principally in the great chains of mountains, where they are ordinarily thrown up, and rest against the primordial schists[1]. I have described these beds in my Eleventh Letter to the Journal de Physique, (vol. xxxvii.) quoting M. de Saussure for the Alps, and M. Pallas for the mountains of Asia; which serves to show the generality of the phenomenon.

37. It is in these beds that we first find vestiges of animals, and these are the remains of marine animals: it was therefore in this period that the sea began to be inhabited. But we shall see, as we proceed, that all the organized beings, vegetables as well as animals, whether marine or terrestrial, underwent great changes, in proportion as the liquid of this sea and

[1] Our author comprises the transition clay slate in his primordial schists, as was usual in his time. WERNER first introduced the class of transition strata, which are intermediate formations between the primitive and the secondary. In those formations we already begin to observe traces of organic bodies; thus, in the Alps, the transition clay slate exhibits, in many places, impressions of vegetables which are at least as ancient as the first vestiges of marine animals; and it is easily conceivable that this must have been the case, since animal life could not have been sustained without vegetables. ED.

the atmosphere varied, as much from the series of chymical operations that formed the succeeding strata, as from the revolutions which the bottom of the sea underwent; so that, through the whole of this process, there will be every where observed, connected with physical principles derived from experience, phenomena of different kinds, which were very obscure, as long as they were considered separately, but which, in their union, all flow from the causes indicated by these principles.

38. By these new strata, which form a very considerable mass, the crust which had been broken in the great revolution of the third period, when the surface of the globe came to be divided into seas and dry land, became so consolidated as to be able to support itself a long time, notwithstanding the immense caverns that were forming within, by the subsiding of the pulvicules, owing to the abundance of the liquid, which, in this revolution, made its way beneath the primordial strata. But as this subsiding, at length, extended itself under the foundations of the walls of those caverns, which had hitherto served as props to the crust, the latter suffered a second subsidence through the whole of its extent, during which it was broken afresh on the same solid walls which had upheld it in its first fall; so that, falling into their intervals, no parts of that crust remained near its former level, except the edges of the broken parts, which, falling, remained inclined on each side of their props, having undergone numerous longitudinal fractures, which formed, in various places, various ranges of eminences consisting of the same strata.

39. Such is the origin of our great chains of moun-

tains, and the beginning of that disorder observed in the mineral strata, of which our continents are composed; a state which I have described in my first letter, and shown to be one of their most important features. The whole mass of the then existing strata, setting out from granite, was broken and shattered on those walls, or solid props within; and the edges of the fragments resting against the sides of these supports, it necessarily followed, that the calcareous strata, which were the most elevated, were thrown to the outside of the chains, and shelved downward, till they were stopped by the bases of these supports; while the granite strata, resting immediately on the summits of these props, remained the most elevated in the centre of the chains. Lastly, that class of primordial strata, in which we find the schists lying between the strata of granite and the calcareous beds containing marine bodies, necessarily formed the intermediate ranges. Such, in fact, is the general arrangement of the different classes of mineral strata in the great chains; which chains, previously to accurate observations, appeared exceedingly embarrassing, and now are our best informers. Not that we have as yet been able to unravel all the circumstances of those catastrophes, or to ascertain with any degree of precision the state of the supports and vacuities beneath the strata, on which state their appearance at the exterior has depended; this can be accomplished only gradually: but much is already done if we have arrived at the idea of a general cause, that shall correspond with general phenomena, and which, accordingly, requires solely more precise determinations. Under this point of view alone, I shall

therefore now proceed to consider the subject, adding only some illustrations.

40. Here then is the third fundamental point to be established, in order to form a history of the earth; for, after having answered these two previous questions, viz. why did the chymical operations, the monuments of which we find on our globe, begin only at a certain epoch? and whence proceeded our mineral substances?—it was necessary to answer these two other questions, evidently connected with each other by some common cause; namely, How comes it that the sea, which must have deposited the substances which compose our highest mountains, is now so far depressed below their summits? and, why are the strata of those substances, which must have been deposited in a horizontal and continuous position, now so variously inclined and broken, and frequently dipping into the interior of the soil? To give an answer to these last questions, while applying to them the causes above indicated, I shall begin with an instance, which will show, from facts that are analogous, how all these eminences which rise in ruins above the general surface of our continents, have been formed, and whence proceed all the varieties we find in the arrangement of the fragments of strata of which they are composed.

41. The autumnal rains often overflow those parts of extensive pasturages which lie lower than the rest of the plain; and the water there accumulated, covers the irregularities of the surface, so as to give it the appearance of a lake. If a frost ensues, all this surface of the water becomes covered with a crust of ice.—To this crust of ice let me liken the mass of

mineral strata, of which I have been speaking, such as they were at first formed at the bottom of the liquid. However, in the first case, by degrees, the water passes by filtration into the soil, and the ice remains for some time supported by the most elevated of the little eminences it had overflowed: but at length it breaks on these props, and sinks down into the intervals between, its edges only remaining at the former level, inclined against the sides of their supports. If any of these solid bodies within should be of sufficient extent to allow of the ice breaking all round, a portion will remain on its summit, lying more or less in a horizontal direction: and if the branches of these props, or small eminences, have interruptions, the ice will break off and fall into their intervals; and its edges, inclined in various directions, will present only a heap of icy fragments. Here then is what happened to the primordial strata. It frequently occurs in the example, that after these first accidents have effected the crust of ice, snow will fall. I would compare the stratum of snow which is then formed on the ice, to those of our strata, which were produced subsequently to the formation of the first rudiments of our great chains of mountains. In the example, all the turned-up edges of the crust of ice will form, as it were, small chains of mountains on the surface that is covered with snow: in course of time the crust of snow will have become hard enough to break with the ice: the water, in the mean time, continues to sink into the soil; the crust of ice and snow subsides; it meets with interior eminences, lower than the former, on which it will be broken, and then fall into the intervals; after which we see

the fragments of the crust of snow (which remain on the outside) resting against those of ice round the small eminences.

42. Let us now apply this process to the operations of nature on a larger scale :—for the crust of ice, formed as described above, and afterwards covered with layers of snow, let us substitute the immense crust of our successive strata.—Instead of those small chains of eminences which intersected the lower grounds of the pasturage, let us take the ramifications of those hard and great bodies, that have been formed amidst the soft substances; and in the place of those immoveable supports, on which the crust of ice and snow has been described as breaking, let us imagine that those hard props formed beneath our strata, were themselves liable to sink down, when the subsiding of the pulvicules extended beneath them. Lastly, instead of the solid soil of our pasturage, which soon puts a stop to the subsidence of the ice, when the water has entirely sunk into the soil, let us substitute the basis on which the crust of the strata came to rest during the successive subsidences, a basis composed of the pulvicules into which the liquid could filtrate into the interior of the globe, by causing them to sink deeper and deeper towards the centre:—then all the general phenomena of our geological ruins, from the great chains of mountains, whose formation I first described, to our hills, and even to the broken and dislocated strata under the soil of our plains, (phenomena which I shall explain in order) will flow from precise causes, founded by analogy, on the example I have been giving. The great valleys that cross our chains, are the places where the inte-

rior props were interrupted, and a considerable portion of the strata fell into the intervals: interruptions less regular, and winding, occasioned much confusion in the inner parts of the chains, by the irregularity in the overthrow of the strata; insomuch, that in some places large masses occur in which their order is reversed, and even where some kind of stratum has disappeared, which, however, is again found in its order at some distance: in other places, the same strata, which are seen dipping in the greater part of the chain, have preserved their horizontal position, some at their original level, others more or less below it. Every where the external disorder may be referred to particular forms of the interior moulds, on which the strata have broken, leaving their fragments resting upon, or leaning round these moulds. Lastly, of the longitudinal valleys, the greater part of which are more elevated than the transversal valleys[1], some are

[1] M. J. A. de Luc, jun. expresses a doubt as to the fact. In the Alps, for instance, the Valais is a large longitudinal valley, which is very low both above and below Sion. In the Pyrenees all the great valleys are transversal valleys, for they originate near a *col* on the summit of the central chain; and in taking a direction from south to north on the side of France, they form nearly a right angle with the direction of the chain. The longitudinal valleys, or those of which the direction is parallel to that of the chain, have very little extent; they are, for the most part, mere gorges or large ravines. On the northern slope (versant) there are twenty-nine great valleys or transversal valleys, which all originate in the summit of the central chain. The number of those of the southern slope on the side of Spain, is twenty-eight. There are valleys similar to these in the Alps, such as those of the Reuss and the Aar. From this description of the transversal valleys of the Pyrenees, it would appear that those valleys have all sorts of levels, according as they are taken

to be ascribed to several longitudinal ruptures of the same kinds of strata during their fall, and others to the separation of two kinds, one of which has slipped either above or beneath the other; and all present their sections towards the interior, and their inclined planes towards the exterior.

43. Ever since this instructive idea of the disruption and overthrow of the strata was suggested to me by M. de Saussure, I have never visited our abrupt mountains and hills without being struck with the evidence of the cause I have here pointed out; so that I could account to myself for all their phenomena, as clearly as if they had happened before my eyes; nor have I ever found any difficulty in producing the same conviction in the minds of such attentive observers as have visited with me those stupendous ruins. For those who have not the opportunity of examining the mountains themselves, I would recommend those exact delineations of their large masses, that have been published by M. Chr. de Mechel, of Bâle, in three coloured plates, two of which are representations of Mont Blanc and Mont St. Gothard, after the models of M. Exchaguet; and the third of

near the summit of the chain or towards their inferior extremity; they are therefore sometimes more elevated, sometimes lower than the longitudinal valleys. Hence it appears that it is hazardous to apply the same principle generally to all chains of mountains. For in the Pyrenees, the longitudinal valleys are absolutely insignificant in comparison to the transversal valleys, and these last have been excavated in the mass itself of the strata; they are neither the effects of the elevation nor of the subsidence of the mountains: such, at least, is the opinion of M. Charpentier, from whose Essai sur la Constitution Géognostique des Pyrénées, M. J. A. de Luc has extracted all that is here related of those mountains. Ed.

the highest part of the centre of Switzerland, after the celebrated model of M. le Général PFEIFER, of Lucerne. But, above all, they should study the engravings, contained in the "Voyages dans les Alpes" of M. de Saussure, a naturalist worthy of his great celebrity, to whom we are indebted for the first clue to guide us through the maze of our great mountains.

44. It is not only the mountains of Europe which attest the cause I have assigned, as accounting for the ruinous appearances just described; it may be traced in the descriptions we have of the mountains of Asia, published by Messrs. Pallas and Patrin; and it has also been acknowledged by M. de Dolomieu in the mountains of Africa. The following is a very remarkable passage on this head, taken from this last author's Memoir on Egypt, which I have already cited: "I know nothing (he observes) but an instantaneous rupture, that could have produced that long range of almost perpendicular escarpments, which the eastern chain of mountains in Upper Egypt presents, and which could have raised their summits above the level of the opposite mountains, with which, had it not been for this, they ought to correspond, as well in height as in the direction of their strata, as they do in the nature of the rocks, of which they consist. I must even suppose, that it was by the violence of such a rupture that this chain is broken transversely into many portions, and that there have been opened three passages between immense escarpments leading to the Red Sea." Journ. de Phys. Dec. 1793.

45. This is the fit place to speak of the metallic veins; and that I may be as brief as possible on this

point, in regard to general facts, I shall refer the reader to a truly classical work on veins, that of M. Werner, of Freyberg, extracts from which I have read in the Journal de Physique for May and June, 1792; for after the facts adduced by this skilful observer, it seems impossible to doubt, that the veins have been formed in the pre-existing fissures of the strata where we find them; and such is accordingly my opinion. Nevertheless, a specious objection has been made to this idea, drawn from the great inclination of some veins; and it is certain that in such a situation the space occupied by the ore could at no time have been vacant; since what is called the roof in veins, namely the upper part of their enclosure, would have fallen upon the wall or inferior part, by which the fissure, if even it could have been formed in this direction, would immediately have been closed up. This is the only objection to which no satisfactory answer had yet been given; and, in doing this away, the fact on which it rests will serve to determine an important point in regard to the revolutions which I have hitherto mentioned.

46. I have said, that in the great revolution of the third period, that in which the crust of the primordial strata sunk down throughout a great part of the surface of the globe, and so formed the basin of the first sea, this crust then broke on the same hard masses within, which afterwards gave rise to our great chains of mountains, and that many fissures were produced in it. These fissures (principally in the primordial schists) are innumerable, as we perceive from the multitude of veins of spar, quartz, and other semitransparent substances, which have filled these crevices,

sometimes also lined with those druses of various crystals, which form the ornaments of cabinets. Such of these fissures, as have crossed the strata to an unknown depth, are become our metallic veins; and we know more particularly from the mines in Cornwall, that they extended quite to the granite. I am far from being willing to attempt an explanation of the manner in which the ore has been formed, that has come to fill up these fissures; for I consider it as impossible to determine any specific process performed in those times, when the state of the elements of all our substances was so different from what we now observe. But this does not hinder us from tracing very clearly the history of these fissures; they were filled up while they were yet vertical, or nearly so, the only direction in which the fissures could have been produced in such masses; but after the great fissures had been filled with the mineral substances which we find in them at this day, those same masses underwent new and great catastrophes, in consequence of which the veins which they contained, were broken and overthrown. This succession of catastrophes has continued up to the birth of our continents; they are especially to be traced in those of the secondary strata, in which are found stratified mines and coal, which, like the mines containing veins, are fractured and thrown out of their place in different parts of their extent; so that we are frequently obliged to seek for their continuation, by piercing the strata, either above or below, or on one side of the spot, where we lose them; which always happens on meeting a bad vein, that is, another species of *gangue*, or adventitious matter, that has come to fill up the new fissure. Thus

the great inclination of some of the veins has been produced a long time subsequently to their formation; it is to be ascribed to the same cause which has fractured them in so many ways, and serves, together with the different accidents of the same kind observed in strata, as well in mountains and hills as beneath the surface of the plains, to throw light on the repeated convulsions which the whole mass of our strata has undergone.

47. After the second great catastrophe of which I have here spoken, a new change produced in the liquid by its impregnation with the expansible fluids, which issued from the caverns, brought about the precipitation of a new class of calcareous strata, the production of which was accompanied with a great augmentation in the number of the species, and a great multiplication of marine animals: their remains are found sometimes in such great quantities, in these beds, as to form a very considerable part of their mass; and it is from this circumstance that M. de Buffon had conceived the idea, in which he has been followed by other geologists, that all our calcareous substances proceeded from the trituration of shells and madrepores, which, nevertheless, is an error, as I have shown in my Eleventh Letter in the Journ. de Physique. The production of the calcareous strata again was general: we know how very common this class of strata is in Europe; and M. Pallas speaks of them in his description of the northern parts of Asia. I have received also, from Bengal, a description by my son, of strata of the same species, forming mountains; and they have been found likewise in the Straits of Magellan, as we may see in the fol-

lowing passage from the Voyage of M. de Bougainville :—" Between Cape Round and Cape Foreward, there are four bays, of which two are separated by a high cape, rising more than 150 feet above the sea, and entirely composed of beds of petrified shells; at its foot, no bottom is to be found with a line of 100 fathoms." This phenomenon, then, as I have just said, is very general throughout our continents; but it is attended with circumstances which it is important to examine.

The parts the more immediately observable in that class of strata, form chains of mountains or hills, where they are broken in every direction; we find there, especially, vertical sections of their entire mass, forming abrupt faces, as well in the interior as in the exterior, where the strata are seen in every degree of inclination, and even frequently subverted; so that considering all the disorder of those chains, we cannot doubt that they are the remains of a mass of strata which formerly extended, at the same level, in a very wide space. This conclusion, to which the mere view of those eminences would lead us, is confirmed by all that we observe both in their neighbourhood and at a distance. We, in the first place, frequently find at their exterior, masses of the same kind, the strata of which dipping under the soil, have their section towards the summit, and rest in that position against the foundation of the steep escarpments; thus indicating, with the greatest precision, the direction which, at its separation, was taken by the principal mass which at one time was united on every side to those ruins. We likewise find in their neighbourhood, frequently even at great distances,

fragments of that mass, forming hillocks, in which the strata have all sorts of inclinations and directions. Lastly, in the intervals of the chains, we find the same strata in numerous places, covered by other strata. If now we add to all these circumstances, that the calcareous strata here spoken of contain a great abundance of marine bodies—the greater part of the same species, of which a great number ceased to exist in the sea as soon as it no longer produced these strata, we shall be led to conclude, that this precipitation, which continued for a long space of time, took place throughout the whole extent of the sea, and that the great intervals observed between the monuments of it which remain, are the result of the fresh catastrophes which again affected the whole bed of that sea.

But why are not these strata observable on the great chains of mountains, or at least are they not found resting against their exterior ranges, composed of the first calcareous beds containing marine bodies, as having at one time covered them? And why does this second class of calcareous strata itself form mountains, on which are not found different species of strata, which have been evidently formed after them, since they elsewhere cover them at lower levels? These two questions have for a long time embarrassed me, and it is only after having taken into consideration the whole of the phenomena, and conferred on this point with one of my nephews, who has attentively observed the Alps, as well as other mountains and hills, that at length I traced its connection with general causes, by considering that all the present eminences on which have not been deposited certain

classes of strata obviously posterior, were too high, in the liquid, already much lowered[1], and consequently too near its surface, to admit of the formation of new strata; and that, subsequently, those kinds of islands, or shallow parts of the sea, have sunk at the same time that the whole mass of the strata sunk afresh, covered by new strata which had not been formed on the more elevated parts. I am led to believe that a great number of particular phenomena observable in the chaotic state of our strata, as well as many exceptions, to that which had at first perplexed me, will be satisfactorily accounted for by this general cause, combining it with those which must have modified it, and of which I shall now proceed to speak.

48. After the formation of these latter calcareous strata, the catastrophes which took place in the bed of the sea were so frequent, and these produced such complicated effects, that it is not possible to assign any fixed era for the formation of many kinds of strata, of which we find, in many places, very large masses, because their associations with other strata, and their accidents, vary considerably: but it is not

[1] "My opinion," says Mr. J. A. de Luc, "quoted by my uncle, that all the eminences on which have not been deposited certain classes of strata evidently posterior, were too elevated in the liquid already considerably lowered, is not reconcileable to the situation of the secondary calcareous beds in some mountains of the Alps and the Pyrenees. Thus the greater part of the high summits of the canton of Berne are calcareous, such as the Yungfrau, the Eiger, the Mettenberg, and the Wetterhorn. These summits command the valleys of Lautenbrun and Grindleward. In the Pyrenees, the most elevated summit is entirely composed of secondary calcareous strata containing marine bodies, namely, the Mont Perdu, with its dependencies, the Marboré, the Brèche de Roland, &c." Ed.

difficult to assign general causes for this confusion, which is itself an important phenomenon; and to this object I shall confine myself. At each rupture of the crust of the strata, a fresh portion of the liquid passed into the interior parts of the globe, and fresh expansible fluids issued out: by these last, new precipitations were preparing in the external liquid; and, by means of the fresh portion of this liquid, that passed into the interior parts, new expansible fluids were likewise prepared, which successively differed in some respect from each other, owing to the changes the liquid gradually underwent, at the exterior, during the intervals of its infiltrations: such is the general cause, which I pointed out from the beginning. Now, if we consider the extent of the sea, the inequality there probably was between different places, in the mixtures of those of the primordial ingredients, which were least disposed to combine, either within or without; and the differences that were thus preparing, as well in respect to successive chymical operations, as to the catastrophes that happened to the strata, in consequence of the modifications of the concretions which were forming or subsiding in the interior, we cannot be surprised at the increasing irregularities in the products of chymical operations, nor at the catastrophes of the strata, subsequently to their formation.

49. Among the phenomena, in regard to which we find the same order of succession in numerous places, but, in respect to which there prevail great variations in others, we must rank our strata of sand-stone, so abundant also all over our continents. In describing

these strata, in my twelfth Letter in the Journ. de Physique[1], I quoted M. Pallas, to show the conformity that subsists between Asia and Europe, with regard to this new geological fact. I shall not revert here to the opinion of those who have attributed these strata of sand-stone to operations which took place, on our continents, subsequently to their birth, because I have already refuted it in the first of these Letters, as covering with the veil of error all our geological monuments; and I am now about to prove, what I had already stated on this head, that previously to the retreat of the sea, those strata have been subjected to the same catastrophes with all those which had preceded, and followed them.

50. In those places where we discover the base of these strata of sand-stone, we find them resting on the last strata of lime-stone that I have described. This leads me to speak of a great phenomenon, namely, the changes that the different species of marine animals have undergone, and to point out how much their existence, and mode of existing, were connected with the modifications of the ancient sea. One of these changes was universal, about the time when that particular class of strata of sand-stone was formed. This was the total extinction of divers species of animals, which we no longer find, either in the strata subsequently formed, or in the present sea: I shall here mention only the large family of the cornua ammonis, many species of ramified and articulated animals, of the kind of the caput medusæ, a class of

[1] Tom. xxxviii. pp. 90—109. 1791.

shells called nummulites, containing many species, and the belemnites, all of which, previously to this epoch, existed, in great abundance, in the sea. But, besides this general change, which was followed by many others, that gradually brought the species of marine animals nearer to those of the present day, there happened then a partial change, that is very remarkable; namely, that wherever the precipitations of those sand-stone strata, of a very common kind, (but which already commenced to be formed partially only) took place, all the marine animals perished; for though these beds are incumbent on calcareous strata, which contain the greatest abundance of marine bodies, and in many places they are covered by strata where they again make their appearance, I have never found any traces of them in the former[1].

[1] Mr. J. A. de Luc has ascertained that no marine bodies have hitherto been found in the molasse, or sand-stone, of the basin of the lake of Geneva; traces of vegetables only have been discovered. Nevertheless, in the cantons of Berne, Lucerne, and St. Gall, there is a marly sand-stone associated with the nagelflue, which contains numerous marine shells, many of which are in his possession. This sand-stone is soft, it has a powerful effervescent quality, and its grains are very fine. A naturalist of Berne, Mr. B. Studer, calls this sand-stone *molasse*; from a calculation of the different species of marine shells which it contains, he has found them to consist of upwards of eighty varieties, all of which have their analogues in the present sea. The bivalves are the most numerous. Mr. Beudant, in the first vol. of his work, p. 159, describing the sand-stone and the nagelflue of the country of Saltzburg, states, that in some spots there are found amidst those calcariferous sand-stones, debris of shells of various kinds which are all of them analogous to those of the tertiary deposits; they are chiefly cardia, venuses, and turritellæ; shark's teeth are also met with. Ed.

51. Nevertheless, those strata, so different from each other, with respect both to the marine bodies, and to their substance, have suffered in common divers catastrophes, of which the first was very great and very general at the bottom of the sea. Subsequently to those scattered heaps of strata of sand-stone, one character of which is their not being hard, so that in some places they are called *molasse*[1], the whole mass of strata sunk down afresh, leaving ruinous fragments of the new strata under the form of chains of hills, on the walls of the caverns which had continued to form beneath them, and where the remainder of the whole mass of strata sunk down again. Now, it is in the abrupt sections of the strata in those chains, as well on the sides of their valleys, as in a number of their external sides, turned towards the plains, that we perceive the strata of that sand-stone either resting on those of calcareous matter, or leaning against them in places where those masses that remained outwards have been overthrown on the sides of their supports. Without these disruptions, and the sinking of large masses between them, and round them, we should probably have been for ever ignorant of what the first of those strata rested upon. In these valleys, as well as in abrupt faces of the outer parts of these chains, we may trace all the

[1] The author seems here to comprise under the same period all the strata of sand-stone, among which he includes the molasse; but Mr. J. A. de Luc is not of opinion that these strata belong to the same epoch. Thus those which cover the mountain lime-stone in Derbyshire, Denbighshire, in the vicinity of Bristol, and in the counties to the north-west of Dublin, are much more ancient than the molasse of Switzerland. Ed.

catastrophes that our last stony strata have further suffered, as clearly as if we had been witnesses of them; proofs of these catastrophes are not less obvious below the surface of our plains, wherever, from some external indication, excavations are made in strata for purposes of utility. Before quitting the subject of the sand-stone strata, I have to observe, that there are several kinds of them, different from those just mentioned, which have undergone the same catastrophes, and together with the same calcareous strata on which they have likewise been formed, but which contain marine bodies. Details on this head would be inexhaustible, in consequence of the variety of strata found in different spots upon those calcareous beds; I shall therefore add only that the strata of sand-stone of which I speak, are in general more indurated and in smaller masses than the preceding.

But here, Sir, it is fit I should stop for the present; for I am approaching two phenomena, which, though they belong to this same period, cannot be noticed in this letter, already sufficiently long,—these are the volcanic eruptions, and the beds of coal. Though I am anxious to be concise in this extract, it is necessary that in assigning the causes of the principal physical events that have happened on our globe, and of which the monuments now exist, I should bring together a sufficient number of circumstances to show the progress which has already been made in this path, and to excite in attentive readers a desire to look into the several works which I quote for the detail of facts and physical principles which I am here under the necessity of suppressing. I am not apprehensive of being thought prolix by those who

will bear in mind that I am here tracing, from precise monuments, the foundation of the ancient history of mankind, since the subject of our discussion is their abode.

I have the honour to be, &c.

LETTER IV.

n the History of the Earth, *from the time of the formation of the calcareous strata, to the last period in which the Sea remained in its ancient Bed; a long space of time, which comprises, in particular, the Origin of Volcanic Eruptions and of Coal Beds; the formation of the strata of Chalk and Rock Salt; and the History of the* Quadrupeds, *of which we find the remains in our strata.*

Sir,

ı my former letter I entered upon the detail of ope- tions belonging to the fifth of the periods into which have divided the ancient history of the earth: and stopped at the point where I was about to speak of ılcanic eruptions; with this phenomenon, therefore, shall resume the series of the events that have hap- ned on our globe.

OF VOLCANIC ERUPTIONS.

1. Volcanic eruptions are amongst those terrestrial enomena that have most excited the attention of mer geologists, both from their indicating the ope- ion of some great cause, and from their true cha-

racters having been long misunderstood. The number of ancient volcanic cones which are to be met with on our continents, as well as of volcanic islands scattered in the sea, gave rise to many systems, in which it was attempted to explain the formation of our continents themselves, by materials forced up from the bottom of the ocean. I have treated this subject in my Letters on the history of the earth, &c. and subsequently, in the Journal de Physique; I shall therefore confine myself here to the consideration of it in a general point of view.

2. The phenomenon of volcanic eruptions is doubtless a very considerable one, when we regard it separately; but it is very slight, when we take in the whole assemblage of revolutions that must have happened to the surface of the globe; and its products bear but an insensible proportion to the mass of strata produced by chymical processes, in a liquid, where marine animals lived and propagated in great abundance, and the bottom of which consequently could not be hardened by fusion, or after the manner of bricks, as Dr. Hutton has of late conjectured, thus reviving an hypothesis which all attentive naturalists had abandoned. These strata, which constitute the greatest phenomenon on our globe, have certain characters that indisputably connect them with all the general causes that have acted on it; while the volcanic substances, raised here and there in patches on these same strata, indicate certain local causes only; and it is in this point of view that I shall consider them.

3. The problem concerning volcanic eruptions involves the three following questions.—1. Whence is

it that these eruptions have issued?—2. By what power have the fused matters been driven out and accumulated on the surface?—3. At what time did those eruptions happen, of which we have no accounts in history?

4. First question.—Many mineralogists have sought to discover, what the strata were that furnish the substances of lavas, and by what means they are brought into fusion; but I have reason to think, that our strata have no share in this phenomenon. The quantity of pyrites found in certain schistose and argillaceous strata, had led some naturalists, and particularly M. Pallas, to fix the focus of volcanos in these. But pyrites do not undergo decomposition and combustion, except when they are exposed to the air; and each mass of pyrites being perfectly enclosed in the part of the stratum it occupies, is entirely protected from that effect. The coal strata have also engaged the attention of some naturalists in this line of enquiry; but besides that they do not lie deep enough to answer the phenomena of volcanos, they are also surrounded by other substances, which prevent their communication with the air, without which they cannot burn. Accidents many times have set coals on fire, in certain mines, where they have even burned for many years. I have witnessed this fact in Staffordshire, and have been informed of all its circumstances: it has not occurred, nor indeed can occur, excepting in mines; the combustion takes place only in the rubbish, and in the pillars that are left to support the superincumbent soil. The conflagration, indeed, occurs, merely owing to precautions not having been taken in time to close all the openings which

allowed the admission of the air; precautions no longer practicable after a certain time, because of the multitude of crevices that are produced in the upper soil; but it stops of itself as soon as it arrives at the solid body of strata, and thus a termination is put to those accidents. Since then neither pyrites nor coals, the only substances of our strata susceptible of combustion, can undergo it in the interior of the earth, we must look beneath our strata for the focus of volcanic eruptions. Moreover, if we consider the prodigious effort necessary for raising lavas to the summit of Etna and the Andes, we shall be convinced that the whole mass of our strata, beginning from granite, will not have been too great to resist a re-action of such extraordinary force.—Lastly, we know that islands have been formed in the sea by eruptions of this kind that have taken place under its waters; a circumstance which forbids every idea that those subterranean fires can be of the same nature with those which we observe at the earth's surface.

5. The circumstance which has given occasion to search in our strata for the substance of the lavas, is, that fragments of these, taken from the interior of their mass, bear in their appearance, and through the ingredients which they afford in their analysis, such striking relations to the fragments of some strata, that the mineralogist might frequently be liable to confound them, were he not apprised that the former have been taken from masses, the external part of which was in scoriæ, and which have flowed from a volcano. But far from this being a proof that the lavas proceed from the fusion of the strata with which they have these resemblances, it on the contrary ap-

pears to me, from the following considerations, that they must evidently be traced to a very different origin. If the substance of these strata, after having undergone the degree of heat necessary for causing it to pass into the state of fusion, retained, on cooling, the same resemblance to the lavas, it would be reasonable to think that it had produced them in a similar manner; but in the course of all the experiments that have been made for this purpose, it has been found impossible to produce with these substances a thick and glowing liquid such as lava; and after cooling, all resemblance has disappeared; the substance has undergone great changes, both essentially and in its appearance: consequently nothing authorises us to think that lavas are the products of those strata by any effect of heat. On the other hand, if the lava which resembles those strata, is again exposed to a degree of heat productive of fusion, it likewise loses its resemblance. Let us now take into consideration, what we know of the immediate origin of those substances, so similar in the nature of their molecules, as well as in the appearance of their aggregation. This resemblance exists between lavas which we know to have been in an incandescent state, and strata produced by simple precipitation in a liquid. It is not, therefore, the strata which are reduced to the state of lava; it is other substances, which no doubt contain the same molecules, but in a different association; and it is not by fusion, that is to say, by the action of an external heat, but by combustion, that these substances are invested with the appearance of certain strata.

6. It is from these considerations on the difference

which has existed originally between the matter of certain strata and that of the lavas which are now analogous to them, but only after having undergone combustion, that I cannot bring myself to think they proceed from those strata, and that I ascribe them to the mud, which, as I have explained in the preceding letter, was in the first instance deposited on the pulvicules at the bottom of the primordial liquid, and on which have been formed all our strata, beginning with granite [1]. This mud, which we have seen to bear an

[1] Granite, remarks Mr. J. A. de Luc, jun. on this passage, cannot always be reckoned in the number of the strata, for in many places, as is now well ascertained, for instance, in the Pyrenees, in Scotland, in Cornwall, at Brocken in the Hartz, that rock is not stratified.

In reference to this important point, the following extract from a letter of Prof. L. A. Necker, grandson of De Saussure, inserted in the Bibliothèque Universelle for Sept. 1826, will be found very interesting.—" With regard to the Alps, and, more particularly, the vicinity of Mont Blanc, the last geologists distinguish two species of granite, the one stratified, and the other not stratified. The first species constitutes all the needles of Chamouni; it is composed of quartz, feldspath, chlorite, and steatite; the mica is of rare occurrence. This rock has been called protogine by M. Jurine, in order to distinguish it from the true granite which is composed of quartz, feldspath, and mica, without assuming the schistose structure. This true granite is not stratified, but exhibits itself in masses more or less irregular or rounded, in accumulations, in veins which invariably intersect in an oblique direction the general stratification of the soils in which they are found; or if it sometimes appears to form strata parallel to those of the soil, which contains them, those strata do not long maintain their parallelism, and re-enter into the class of strata traversed by metallic veins. The protogine, or chloritic granite, is always stratified. In proportion as the protogine, under all its forms, and in all its varieties, abounds in the Alps, in the vicinity of Mont Blanc, of which it forms the most elevated summits, in the same proportion granite, properly so called, is there seldom to be

important, and, according to my views of the subject, an indispensable part in all the operations which I have hitherto traced from their monuments, was already composed of molecules of different species, which continued for a length of time to be formed in this same liquid. But instead of these molecules being, as they were afterwards, precipitated in associations which admitted of their aggregating under the form of stony strata, they were at first intermixed with many ingredients which prevented that aggrega-

met with, and is little known, especially in respect to its position. The only spots where, to my knowledge, it is found, are in the valley of the Valorsine, and at Baveno, at the southern foot of the Alps."

When De Saussure spoke of the stratification of granite, it would appear that he spoke only of the protogine. M. Alex. Brongniart, in his Tableau des Terrains, &c., 1829, establishes a distinction between the neptunian or stratified granite, and the plutonian granite, p. 33.

Respecting the origin of granite, the following views of Mr. J. A. de Luc, the younger, have been communicated by him to the editor. "I do not," says Mr. de Luc, "agree with Sir Alex. Crichton, that the granitic crust is a crystallization arising from fire. That writer deduces the proof of it from an hypothesis which I do not admit, namely, that the crystals enclosed in lavas have been dissolved by the heat of a volcano, and formed in the liquid lava. Such crystals have been produced previously to the fusion of the lava. In regard to granite and other primitive rocks, I conceive that I have demonstrated, in a Memoir on the aqueous origin of rocks, that water had a very great share in their crystallization. Bibl. Universelle, tom. x. p. 161. et seq. The opinion of Sir A. Crichton, that the nucleus of the earth, 'still is in part, in a completely metallic state,' is altogether gratuitous, as well as his hypothesis that granite is to be considered as a mass of earthy oxides, which were produced by the action of air and water, or aqueous vapours, on the metallic mass." Ed.

tion. We have seen the necessity of seeking beneath the liquid a source of new substances which must there have successively ascended, producing in it new combinations, and the disengagement of fresh expansible fluids. Now the first operations in this mud (or thick paste) might have generated fluids productive of that effect, previously to the liquid having very deeply penetrated into the pulvicules, where for a long time, by occasioning their subsidence, it produced a succession of new fluids, and consequently of new combinations, in the upper part of the liquid. It was after the first modifications of the mud, by the separation of some of its ingredients, under the form of expansible fluids, that in some places it underwent a degree of heat owing to the disengagement of a great abundance of fire, in consequence of chymical operations in its mass, which brought it into an incandescent state, at the same time that it produced different species of expansible fluids out of those remaining ingredients which had hitherto prevented its other molecules from aggregating under a stony form; and it is after this operation, which is not productive of an excessive heat, that the remaining mass bears a resemblance to some of our strata.

It is thus also we are enabled to explain the phenomenon of a great number of crystals contained in the lavas, and which, although fusible, have undergone in them no alteration. The different molecules being thus aggregated in small regular masses, had formed in the liquid, at the same time with all the other molecules of the mud; and these small masses might have been formed and become larger, either during their very slow descent in the liquid, the spe-

cific weight of which was then much greater than that of its residuum (the water of our sea); or in the mud itself, which, mixed with much of the liquid, opposed but little resistance to these aggregations. All these crystals then were in the primordial mud, and are likewise in what remains of that mud beneath our strata; and when combustion takes place in it, it does not acquire a degree of heat sufficient to dissolve them; so that they are preserved in its substance when the spontaneous combustion ceases there. These crystals have indeed a great resemblance to those belonging to our strata, the names of which have been given them; but, when attentively examined, essential differences are observable in them, which will not allow of their being confounded.

7. It will not be expected that I should point out the specific progress of those operations: for although every physical explanation of the great operations that took place in the first periods of the earth, must be grounded by analogy upon known effects, of which we are able to observe all the circumstances, it is very evident that a generic analogy only can be applied in such an inquiry, since nothing of the same kind is operated at this day. But we have a particular test of those explanations, and in having regard to it, we cannot wander far from the truth: it is that as all great geological phenomena must necessarily be connected with each other by common circumstances, depending on the periods of time during which they have been operated, every cause that is assigned to each of them, considered apart, must be consistent with our judgment of the whole. The same general causes do not produce the same effects, when circum-

stances differ; circumstances peculiar to the first periods of the globe, determined those causes to operate effects which they no longer produce in the present state of things; and the monuments of all the phenomena of those times are not more numerous than are absolutely necessary to guide us in the research of the modifications, which the effects of general causes have there undergone, in consequence of circumstances no longer existing. I have endeavoured to abide by that principle in the establishment of all the parts of my theory, and it is more particularly after an attentive examination of all the other great phenomena, that I perceive no other assignable origin of volcanic eruptions than what exists in substances confusedly accumulated in the first instance at the bottom of the primordial liquid, previously to the formation of any stratum, properly so termed, and consequently, before the formation of granite itself.

8. Second Question.—When this thick and glowing liquid was formed at the depth pointed out by the preceding considerations, what was the agent which could drive it out and raise it to the summits of such volcanic cones as Etna and the Andes? In general, it was the expansible fluids: but those which we call permanent or æriform, are not sufficient to explain our phenomenon; it is the aqueous vapour or steam which has been the agent. If a sufficient quantity of water is any where confined, this fluid becomes there more and more dense, in proportion to the increase of heat, and capable thus of acquiring an immense power of expansion; but it decomposes inversely as the heat diminishes; with this additional circumstance, that it is suddenly and entirely de-

stroyed from the first sensible diminution of the heat, when the same pressure continues to be exerted upon it: this I have shown in my "Idées sur la Météorologie."

9. It is a fact, that in the interior parts of the earth, great accumulations of incandescent materials are often formed, and it is accordingly sufficient that a certain quantity of water should find access to the caverns which contain those materials, to produce suddenly such a supply of vapour as is capable of the most violent efforts. Let us suppose that there is an opening in the walls of the cavern, but that it is obstructed by the matter in fusion: the vapour will exhaust its power against that less resisting part, and force those materials up to the surface, till at length, it makes an outlet for itself; for as long as it is confined, and that there is any water remaining within, there will be no limits to its action (which is always proportional to its density), but that of the quantity of fire.

10. It is thus that the enormous heaps of lava which form the substance of the great volcanic cones have been produced. A passage has been preserved through these masses, by each eruption of lava (that is, of that quantity of fused matter which at any certain time has risen to the inferior opening,) having terminated generally by explosions, or violent discharges of the expansible fluids, making their way through the last matter that was raised; which explosions produce the showers of loose substances which we call volcanic ashes. The subsequent eruptions always produced by fresh accumulations of liquid matter obstructing the opening below, pursue

the same route, and terminate in the same manner. The channel or passage is thus continued, provided it does not become obstructed by some demolition, or by the lava cooling and hardening within it. In these cases the vapour being pent in, acquires very considerable force; it shakes the soil, and at length produces an eruption of lava in some lateral part where it meets with less resistance. So long as the lavas continue to pass upwards through the same channel, which suffers only an increase of its length, and that the explosions of disunited matters, called volcanic ashes, in like manner issue forth by the same passage, these different matters, spread over the outside, are accumulated in the form of a cone, in the same manner as the earth is accumulated round the openings that moles make in the ground in digging their subterraneous galleries. But if these accumulations increase considerably on some base which in time becomes incapable of supporting the weight, or which, from any cause within, subsides, the cone falls in, and nothing remains externally but the irregular circumference of the base, or the edges of the lava that had flowed from the summit or the sides.

I have given in my first geological work some striking instances of these catastrophes, which I have observed among heaps of ancient volcanos in Germany; they consist of enclosures of hills of greater or less extent, each of which presents, in the interior of the circular ridge, the section of the inferior part of numerous lavas, intermixed with ashes and scoriæ. We have an example of this, on a small scale, in Vesuvius, the present cone of which has been raised on the ruins of an ancient cone, much more con-

siderable, to the base of which belonged Mount Somma. The bottom of some of those circular ridges is at this day the basin of a lake. This phenomenon would alone be sufficient to show, how forgetful systematic men must have been of the principles of physics and mechanics, when they supposed, that subterraneous fires could have raised our continents themselves above the sea, and left them, through their whole extent, suspended at this height.

11. We may discover, in another phenomenon, the fluid which raises lavas; for, to the greatness of the effect produced to which no other fluid can be conceived equal, we are to add the cessation of this effect, without any other symptom observable at the exterior: I speak of earthquakes, which likewise show the great depth of the source of the lavas. How can it come to pass, that such extensive tracts of land, traversed by immense chains of mountains, should be shaken at one instant, by the production under ground of a sufficient quantity of a particular fluid; and that the effect nevertheless should cease, without this fluid making its escape outwardly, with a violence capable of overthrowing the mountains themselves? Because this fluid is not an air, but the aqueous vapour, which, remaining under the same pressure, is destroyed as soon as it loses that portion of heat by which it had been produced.

12. And thus the solution of the phenomena of earthquakes embraces the greatest of our geological problems. For the production of these effects, it is first requisite that our continents should cover large caverns, which, through a great extent, communicate with each other beneath all the strata. Now I have

already sufficiently shown, that the very production of a succession of different strata, and the catastrophes they have undergone, require that caverns should have been successively formed beneath them: so that the caverns now existing, are some of the remains of those. It is necessary also that there should be, in some parts of the interior of the globe, heat capable of producing suddenly a prodigious quantity of aqueous vapour of considerable density; and we know, by the present volcanos, that there must be in many of the caverns certain substances in fusion. It is necessary that a great quantity of water should suddenly flow in upon these substances: and the number of caverns we find in our mountains and hills, show us sufficiently in what disorder our strata have remained, for us easily to comprehend how quantities of water may be gathered in the interior parts of the globe, which from time to time will be breaking their dikes, and flowing into these furnaces. In such cases an earthquake is produced; which ceases without any outward manifestation of its cause, from the vapour soon penetrating into other caverns, and fissures of the strata, there losing its heat, and so becoming condensed into water.

13. Third question.—At what period was it, that those great volcanic eruptions began, and principally happened, the monuments of which remain, but of which we have no historical account? I refer these events to the period I am treating of, subsequently to the production of the great mass of strata of calcareous stone which contain but few marine shells, because we find a number of volcanic cones and dispersed lavas, which have been enveloped by calcareous strata abounding in marine bodies, as well as by strata of

sand-stone. These eruptions, therefore, took place while the sea still covered our continents, and the volcanic cones were raised beneath its waters; as, in our time, l'Isola Nuova, the new island in the Archipelago.

14. I shall not now stop to notice the idea of those who, observing the alternations of lavas and calcareous strata, in some places, and the calcareous strata which envelope some volcanic cones, have thence imagined that the sea has many times overflowed our continents; having already shown, in my other works, that this is an useless supposition, and contrary to every geological phenomenon. Neither shall I recur, and for the same reason, to the notion of those, who, taking the volcanic ashes which they find interposed between the lavas of some volcanic cones, for decompositions of these lavas by long continued atmospheric operations, and so counting, in the abrupt sections of the sides of certain cones, (such for instance as Etna) the successive returns of this phenomenon, have thence concluded, in contradiction to all the phenomena which irresistibly prove our continents to be very modern, that they are of a prodigious age [1]. I therefore shall observe only, that these large cones began to be formed in the sea; and that then also, when the lavas ceased to fill their channel, and the expansible fluids first issued forth, there followed explosions of volcanic ashes, which spread over the lavas, and extended far beyond them. I have given a description of the plains in the environs of Coblentz, the soil of which

[1] The author here more particularly alludes to Brydone. See Townsend's Vindication of Moses, Vol. I. p. 423. Ed.

consists of beds of volcanic ashes and pumice-stone, spread out by the sea, like our beds of gravel. This phenomenon, as well as some others which I have observed among ancient volcanos, lead me to believe that further eruptions of this kind took place at the epoch of the birth of our continents.

15. I hope that this abridged discussion of what relates to volcanos, may suffice to show, that this is a phenomenon, which however great in itself, is to be considered as a particular one: that it is without doubt connected with the general causes of the events which have happened on our globe, but that its effects have been local; and that if it were not for the accumulations of volcanic matters which we find occasionally on our continents, in places where the strata are not in greater disorder than every where else, we should be ignorant of any other subterraneous ignition having taken place, than what is manifested in our present volcanos. It even appears that the time when the calcareous strata, containing marine bodies, (succeeded in many places by strata of sand-stone), were formed, was one of the most tranquil periods with respect to the bottom of the sea: which supposes that the crust of strata rested again on the solid supports which had been formed by concretion in the mass of incoherent substances. But vast caverns were forming between these supports, by the subsidence of these substances; and when this subsiding extended beneath the supports, these last sunk, but unequally, and the mass of strata again underwent a very great catastrophe, during which the principal part of the crust subsided afresh; and the portions retained on the props that remained firm, constitute at this day most of our

mountains of the second rank, and of our hills, which bear all the characters of ruins.

16. I have already had frequent occasion to advert to that great cause which acted in the ancient operations on our globe, to which we are led by all the phenomena, many of which are unintelligible without it: namely, that as fast as the caverns were formed, they became filled with different kinds of expansible fluids: so that, when the superincumbent strata sunk down, and the liquid penetrated to the bottom of the caverns, these fluids rushed out with violence, driving before them the fragments of the strata they met with in their passage[1]. This effect was, at the epoch I am speaking of, very considerable, and to that period must chiefly be referred the phenomenon described in my first Letter, of the blocks of granite and other primordial stones that we find on our calcareous and sand-stone mountains, and above all in the disruptions that form their valleys. These great masses resisted the agitation of the waters during these convulsions; but the lesser fragments, which were in great abundance, and some of them even of considerable size, being violently crushed against each other, were in some places accumulated in hills, and elsewhere disseminated at the bottom. Hence were produced some breccias, or strata of pudding-stone; as in like manner, during subsequent revolutions, were formed the gravels of primordial stones, which we find in our loose strata, frequently intermixed with marine bodies.

17. In each of these revolutions, the expansible fluids as they issued from the caverns, impregnated

[1] Journal de Physique, Tom. xxxviii. pp. 105, 106. 1791.

the liquid with some new ingredients, and so produced a change in the nature of the precipitations: this is manifested by the superposition of strata successively different, one of the greatest of geological phenomena, which considering the long duration of each kind of precipitations, and their obvious changes, from time to time, necessarily indicates a cause of that nature. During these precipitations also, the expansible fluids which were disengaged from the liquid, successively varied in their nature; and thus it was that our atmosphere, that confused assemblage of fluids which astonishes none but naturalists, was formed; and it astonishes them, in proportion as they are enlightened and attentive. In truth, whoever carefully studies meteorological phenomena, and their connection with the operations that are successively taking place on the earth's surface, will soon perceive, that we are yet only in the infancy of our knowledge of that laboratory of nature on our globe; that a great number of the fluids, that are employed in operations, of which we are witnesses, are as yet totally unknown to us, and that we even know but very little of those that fall immediately under the cognizance of our senses. This I have pointed out in my "Idées sur la Météorologie," and in many others of my works.

18. If next we come to consider the consequences that these successive and correspondent changes in the liquid and the atmosphere, must have produced with respect to the organized beings, to the subsistence of which, as they severally were the inhabitants of either, they contributed, we shall be no longer surprised at the changes, which the marine as well as the land animals and vegetables have undergone, any

more than at the total extinction of some of their species, in either element. On the contrary, what our strata unfold to us of the history of organized beings, naturally connecting itself with the causes already set forth, will serve as another proof of them. I shall not enter into any great details on this subject, as they are to be found in my other works; I have already stated some particulars respecting the marine animals, and shall now advert to others which relate to terrestrial vegetables, necessary to the explanation of another great geological phenomenon, now about to be mentioned.

OF COAL BEDS[1].

19. The strata of coal, by the great utility of that substance, in regard to its combustible qualities, have procured us information, with respect to the past states of our globe, which we never should have obtained but through this object of public interest; for naturalists would never have attempted to dig so low, and in so many places, beneath the surface of the earth, merely through a spirit of research. I have shown in my "Lettres sur l'Histoire de la Terre," &c. and in the thirteenth and seventeenth of my letters in the "Journal de Physique[2]," that the substance of coal was formerly peat; and I believe it is now not doubted. But those

[1] M. Alex. Brongniart readily acknowledges that the theory of coal formations, which appears to him the most probable, although proposed long before geology had acquired all the facts which it now possesses, is that of De Luc. Tableau des Terrains, &c. p. 280. 1829. Ed.

[2] Tom. xxxviii. p. 174. et seq. 1791. Ibid. Part ii. p. 332. et seq.

vegetables, the remains of which having withered and become dissolved without undergoing decomposition, formed that peat, were very different from those which at present produce the ingredients of peat on our continents: this is observable in the stony strata which covered the former, where are found impressions of vegetables which grew at the surface of that ancient peat, and from which they proceeded. Among these impressions, we discover some vegetables which grow at present in the same latitudes, such as the sphagnum palustre, and some of the junci[1], which form a great part of the mass of our peat, as well as many known ferns; but, in the first place, these last do not belong now to our climates. In addition to which I shall observe, as a peculiar object of consideration, that the vegetables, now unknown, which have contributed to the formation of coal, are not the only monuments of the first vegetation on our globe, which prove that vegetation was in a very different condition from what it is at this day; for we find them likewise in some strata of sand-stone, where we see, among others, the remains of immense tubular and ramified vegetables, to which there is nothing similar among our own. I have designated under the title of THIRD PERIOD, that at which the earth's surface was for the first time divided into sea and land; and while indicating that period as corresponding to the third DAY recorded in the first chapter of Genesis, I observed, that in this "day" the earth was not as

[1] "The vegetables of the coal-pits, properly so called," says Mr. J. A. de Luc, on this passage, "are altogether different from our present plants. The information given to the author, respecting the sphagnum palustre, and the junci being found in the coal, must have been erroneous." ED.

yet enlightened by the sun; such is the fact which I have now to consider.

20. Whatever difference there may be between the first vegetables, and those which exist at the present day, had we no other guide in the history of vegetation, we should not assuredly have inferred from thence that those first vegetables were deprived of light. But I shall first propose here a general question of great importance: what would man have been capable of discovering in regard to the origin of the world without Revelation? This question is not a speculative one—it can be resolved by facts alone; and although it is here anticipated, because it is connected with numerous objects which can be developed only in succession, I could not pass by this period in the history of the earth, of which we at present observe the influence, without determining the objects for our consideration in respect to the knowledge acquired by man. I shall show hereafter, relatively to this subject, that all the notions of cosmogony disseminated amongst the most ancient nations, have proceeded alone from Revelation itself, and that all they have added to it, in regard to which there exists no appearance of researches, are mere chimeras, grounded upon those first foundations. But what we may already perceive at this stage is, that Revelation, preserved in all its purity among one of those nations, is the true cause of the progress which mankind has made in the study of nature, and the only guide that has directed them in it; for if we carefully follow out the history of geology, not through the vain fancies of ancient nations, but among men who have at length applied to the study of the actual state of the earth,

in order thence to deduce physically its past states, it will be seen that those researches have all had Genesis in view, whether for the purpose of attack or defence; researches which the pagan cosmogonies, although having in reality the same origin, never have, nor ever could have, suggested. It is the plain narrative of Moses, without details, but exact in respect to the order of events, that has led to the examination of geological monuments, and to the study of chymistry and general physics, as directed to the investigation of the causes which could formerly have produced such great effects upon the earth, and many analogous effects upon the other globes; and it is on reflecting more particularly upon these important words at the beginning of Genesis: "And God said, let there be *light!*" that we have succeeded in discovering in them a sublime truth, insomuch that none of the great physical effects which we perceive to have been operated, not only upon the earth, but upon other globes, could have commenced without the addition of *light,* to the other substances which at first constituted the mass of those bodies. What confidence then ought not to be inspired by so exact a confirmation of the most important among the passages of Genesis that had been charged with absurdity, as placing effects before causes—for here all nature attests the necessity of the pre-existence of light to all the physical operations of which we see the effects upon the globes, and in particular that mission of the light which causes the splendour of the heavenly bodies. Now, although we have not as yet found such direct proofs of the pre-existence of vegetables to the emission of light by the sun, we

have, nevertheless, observed circumstances which no longer allow us to consider it as absurd[1]. We know, I say, on one hand, that the action of an external light upon the planets, necessary at present for the fructification of the greater part of vegetables, is attended by alternate emissions and absorptions of expansible fluids, or of modifications of the surrounding atmosphere, according to certain circumstances, partly connected with the absence or presence of light, but in part likewise with the nature of the vegetables, and with the different states of the air that surrounds them; which in the first place shows that the necessity of an external light may be dependent on circumstances, for we are far from being enabled to determine the manner in which it acts, and in what respect it is necessary in the vegetable economy, which is still involved in mystery. On the other hand, we learn, through geology, that our atmosphere must have been formed, and have experienced great successive changes, in proportion as our mineral strata were produced in the liquid which once covered the whole globe; that when by a first catastrophe of the bottom of that liquid, new lands were formed, the first vegetables which grew there, were very different from those which our globe now produces; but that in proportion as the atmosphere approximated to its present state, plants, and together with them, marine and terrestrial animals, in like manner approached

[1] It has been ascertained, that even in the present state of the globe, vegetable existence is not altogether incompatible with the absence of light. Caverns and mines are said, by HUMBOLDT and other naturalists, to produce certain plants, principally those of the cryptogamous class. ED.

still nearer and nearer to the species known at this day. When, therefore, I read in Genesis, that vegetables began to grow upon the earth before it was enlightened by the sun, far from imagining this an absurd assertion, I see an additional proof of the truth of the Mosaic narrative, for had the author written a fable, unwilling as he must have been to offend the common sense of mankind, he would assuredly have avoided assertions which must necessarily appear to them absurd; but he addressed himself to the Jews, who had proofs of his mission; and stated, without hesitation, only what he was commanded to declare. It was incumbent upon me here to set forth this great character of truth in Genesis, of which we shall hereafter find more direct examples, viz. that the very circumstances which had been the most strongly objected against that sacred book, for want of sufficient knowledge respecting the objects to which they referred, being nevertheless verified, are those which at this day prove, in the most evident manner, the divine mission of Moses. I shall now resume the history of coal, as furnished by the phenomena which that substance, now mineralized, though proceeding from vegetables, presents.

21. In order to take a right direction in the discovery of the causes which produced the change of the ancient peat into our coal strata, and which have reduced the latter to the state in which we now find them, we must first consider, that these products of vegetable matter are inclosed in stony strata, in which marine bodies are found: by which we see, that the peats, from which they proceed, have been submerged, and that in this state they have been

covered by strata produced by precipitation in the sea. We perceive besides, from that undoubted fact, why the stony strata which inclose those of coal, though in many respects they resemble other strata formed elsewhere in the same period, have particular characters that distinguish them; for instance, we always find there argillaceous strata, containing much iron ore, scattered through their mass, in nodules, which often contain within them impressions of vegetables. With regard to this, it must be remembered, that at those times, when the liquid of the sea still contained the elements of many sorts of the future strata, the successive species that were forming depended in part on the nature of the new ingredients which produced the precipitation. Now the submerged peat gives us a general idea of a source of fresh ingredients proper to determine particular precipitations; at the same time that this peat itself underwent corresponding modifications, in consequence of which it was mineralized under the form of our coal.

22. If there were need of any further proofs, than those which I have given in other works of the origin of coal, as proceeding from peat which underwent submersion by the waters of the sea, we should find such in the fossil peat, which differs from coal only in this, that it has not been mineralized, and that the strata which cover it do not contain ferruginous masses; for, in other respects, the circumstances are the same. I have spoken of these beds of vegetables in my seventeenth Letter in the Journal de Physique, Vol. xxxix, where I have given the result of my observations on the Steinberg, the Veisner, and the

Robelberg[1], mountains of Munden and Hesse, where this phenomenon is found to correspond with what we observe in some parts of Switzerland and England. The vegetable substances are still very distinct in these beds, in that at Veisner in particular, which is thirty feet in thickness; we find in them a quantity of the trunks, branches, and roots of trees, as in our present great peat lands. Now these vegetable beds are fossil; for they are covered by strong strata; and those which I have observed could not have been discovered, had they not appeared in the abrupt sections of the strata of which they constitute a part, forming steep hills on one side, while on the opposite side their strata are much inclined; the manifest effect of the same catastrophes which have produced hills composed of other species of strata.

23. It remains now to enquire what has been the cause of this submersion of the ancient peat, repeated even many times in the same places, as well as of the catastrophes which its beds afterwards underwent; events which we trace in the coal-fields, as it were in the archives of the country. One fact still serves to guide us in this research; namely, that those masses of strata in which the coal lies, are always in some

[1] "The beds of vegetables, or ligneous strata of the Steinberg, the Meissner, and the Robelberg, are not coal," observes Mr. J. A. de Luc, the younger, on this passage, "but lignite, of which the formation is much less ancient, and of which the vegetables are very different from those of coal. This last does not contain wood; the author, then, was in an error when he spoke of the wood and peat, whence the strata of coal have been formed. (See the 17th Letter to the 'Journal de Physique,' Vol. xxxix. p. 346.) I understand by *wood* the solid part of trees, such as fir, oak, poplar, &c." Ed.

manner inlaid in the masses of the more ancient strata. Well informed miners, when they have a sufficient practice in certain coal-fields, know all their strata as they severally lie one above another; so that, as soon as in digging they meet with any of these stony strata, they know towards what point of the horizon, and at what distance, they shall find a particular stratum of coal. But such knowledge, which may apply to one district does not serve for another: a miner who removes to another country, and finds coal, can only carry with him to his new district the general principles of his art, by which he must begin to study all the strata of his field. It is thus that in course of time the miners of any country come to understand the extent of their coal, that is, of the field in which they have a prospect of finding it; or to determine at least its boundaries, which are in every direction indicated by soils of very different species: oftentimes by strata of calcareous stone, which, if inclined towards the former, always pass under them, or present to them abrupt sections.

24. Since the stony strata which enclose and surround the coal contain marine bodies, this is still a further proof that they had originally a position nearly horizontal; nevertheless, we find them commonly considerably inclined, and sometimes nearly vertical —so that they have undergone, it is plain, the same catastrophes of which we have already seen so many instances. When the beds of coal are much inclined, the miners are commonly impeded towards the bottom, before they have dug them thoroughly down, by the difficulty of drawing off the water; which circumstance has led some naturalists to think, that the coal is con-

tinued very low into the earth: but in this they erred; for the same strata which the miners thus abandon towards the bottom, appear again further on, and even repeatedly, towards the top; so that it is certain that all these masses, now distinct, are parts of one and the same mass, formerly continuous, the broken portions of which have fallen on one side, and rest one against the other, as in the case of the strata of the great chains of mountains. Thus the object of the chief miner is to discover all these portions of the same assemblage of strata which prevails in his field; a task of no small difficulty when the country is intersected with hills; for the separate portions do not always incline towards the same point, and I have, for instance, seen, near Aix la Chapelle, the same bed of coal, broken in such a manner, that the vertical section, perpendicular to the directions of its planes, forms an N, the outer angle of which at the top belonged to a hill, and the inner angle at bottom was beneath a valley. Lastly, the portions even of the first mass, which taken altogether have sensibly the same inclination, are often interrupted, in the same manner as the metallic veins, by internal sections, by rubbish, and by other substances confusedly accumulated in the space which at first remained vacant, at the moment of the fracture; but there is not the same difficulty in recovering the displaced portions; for as soon as the pitman has discovered, beyond those substances which form as it were a bad vein, the stony stratum which occupies the place where the coal ought to be, he can easily judge where he shall find the latter again.

25. The phenomenon of coal being thus described

according to its true characters, connects itself in many points with the general causes before explained, and it remains only to ascertain its peculiar features. I have already stated, why, in the revolutions that happened to the ancient sea, islands came to be formed: it was because fresh quantities of the liquid having penetrated through the fractures that were made in the crust, and its surface thus sinking at the exterior, those portions of its bottom, which had not sunk so low as the rest, were then left dry. Now it was upon some of these islands that the peat was formed; in the same manner as it is formed on numerous islands of the North Sea. I have likewise shown, from very striking phenomena, that the supports on which those portions of the crust, which, in the catastrophes that happened to the bottom of the ancient sea, rested, were themselves exposed to subsidence, when, in the course of a period more or less long, the action of the liquid on the interior pulvicules extended beneath them. Then the portions, which had been thus supported for some time, themselves sank down, and if they happened again to pass under the surface of the liquid, there they received a fresh accumulation of strata. Here then, I observe, is a general cause, which, in its different modifications, is impressed in a thousand several ways on the surface of our continents, in such sort that the phenomenon of coals is only a branch of them, modified by the peat. When the islands, of which I have been speaking, came to sink, the peat was covered with other strata, owing to the precipitations that continued to take place in the liquid. When afterwards a new quantity of the liquid was absorbed in any part, and

its surface sank sufficiently for those islands again to appear, fresh peat was formed on them, which again sank beneath the liquid, by a new depression of their base. Lastly, in some of the subsequent great revolutions at the bottom of the sea, these masses, composed of vegetable and mineral strata, underwent a very great catastrophe; they broke and sank down afresh, and the state to which these strata were then reduced, differs nothing from what we observe in our mountains, except that they belong to a lower stage of ruins, by the very repetition of their subsidences; this is likewise the case in regard to all our plains, in which the same disorder is observable, whenever there is sufficient inducement to be at the expense of making deep excavations in them.

OF THE STRATA OF CHALK.

26. The production of chalk is an operation which I also place in this same period, but in coming to it immediately after having treated of the formation of coal, I do not pretend to follow the order of time. This order, indeed, is marked with precision in each place, as much by the superposition of strata of different species, as by the traces of successive accidents: the same successions are also repeated in a number of places, but they are not general, and we find in the intervals other kinds of successions, also more or less frequently repeated, as well as numerous monuments of more particular effects. It is only, therefore, by persevering in our observations, that we shall be enabled to unravel this chaos; in respect,

however, to the general course of the operations, no doubt can arise.

27. Certain naturalists, who from want of sufficient knowledge of mineral substances, or from inattention to those which have preceded the existence of marine animals—who even have never thought of enquiring whence those animals could have derived the substance of their shells and other habitations, have imagined that all fossil calcareous strata have been produced from their spoils; and they consider chalk as a first state through which these substances have passed before they became lime-stone; but the following are direct proofs of the contrary. Owing to the catastrophes which the entire mass of our strata has formerly so often undergone, we observe in many places the superposition of chalk upon the lime-stone, in large sections of the two kinds of strata, forming abrupt faces in some hills or cliffs on the sea-shore; and here we find that the first stratum of chalk, namely, that which rests on the lime-stone in contact with it, is likewise similar to all those of the same mass, so that the two classes of strata are completely distinct from one another. How then is the supposed effect of time here perceptible? Each of these classes of strata contain marine bodies, but they differ considerably from each other; for, to confine myself to one instance only, in the lime-stone, we find quantities of the cornua ammonis, of which we have no traces in the incumbent chalk, which serves directly to prove, that the liquid of the sea had undergone some essential change at the time when these last strata were formed, as it affected, not only the precipitations, but the sea animals. Lastly, one of the

characters of the chalk is, that it contains a great abundance of flints, some of them forming, as it were, a pavement between some of those strata, others disseminated through their mass, and likewise forming some veins. These hard bodies would again recur in the lime-stone below, if it were only more ancient chalk; but we do not find them [1].

[1] At the time when I wrote this first demonstration of the error of those who have imagined that chalk was a first state of calcareous stone, which differs only by a greater hardness produced by time, although I had observed, in various countries, and with great attention, calcareous strata, and their extraneous bodies, I had no where seen any that contained cornua ammonis, or that were without flints; and it was those chalks which I had seen resting on strata of calcareous stone, containing no such flints, and where cornua ammonis were abundant; a circumstance which sufficed to show that calcareous stone and chalk were very distinct precipitations in the ancient sea. But I have here a new fact to adduce, which leads me to make a general remark: viz. that when in certain spots we find abrupt changes of certain strata to other strata of different species, we may likewise elsewhere meet with gradual transitions in the same beds; and this is in particular the case in respect of calcareous stone and chalk. Of this, I am about to bring an instance, which will confirm what I have said in the text, of the influence exercised over organized beings, living at the bottom of the ancient sea, by the changes of precipitations which took place in its liquid; and at the same time there will hence result a new degree of probability in favour of the opinion given in the next section, on the origin of silex.

One of my nephews, another of whose observations is mentioned in that section, having passed some time in the neighbourhood of East-Bourne, on the coast of Sussex, availed himself of the opportunity thus offered for studying with care the strata of which the cliffs of that coast are composed. From Beachy-Head to East-Bourne, the coast runs from S.W. to N.E.; its cliffs, as is always the case, are a section towards the sea of the hills of the country; and along one of those cliffs, the greatest elevation of which, at Beachy-Head, is about five hundred feet, on following the beach,

28. I have stated, in the eighteenth and twenty-fourth of my Letters in the "Journal de Physique," my reasons for believing that the flints are local trans-

the sections of different species of strata are found, which all rise towards the N.E. in an angle of from ten to fifteen degrees, and terminate upwards; for their irregular sections form the upper part of the cliff, as well as of the hills to which it belongs, which hills themselves terminate abruptly towards East-Bourne. That peculiar situation of the strata allows of their being observed separately without quitting the beach, where their abrupt section terminates like a wall, against which the waves, during the high tides, have formed a strand. Thus then, following the foot of the cliff, all its strata are successively seen throughout a considerable extent, by reason of their slight inclination, from those which were formed the first, and which terminate towards its extremity on the side next East-Bourne, to the last, which constitute the greatest elevation at Beachy-Head.

The former of those strata, which are truncated to the N.E. towards the part where the cliff ceases, are of calcareous stone, without flint; and contain, among other shells, many cornua ammonis. Upon this first kind of strata, there rests, with the same inclination, another very distinct species, which, like all the others, constitute successively from N.E. to S.W. for a certain space the foot of the cliff. Here we already find chalk, but it is grey, and its strata have different degrees of hardness; there is as yet no flint; and with regard to the shells, which are there of different species, the softest strata, those which lie nearest to the calcareous stone, contain like it cornua ammonis; but they are no longer met with in the following strata, which are harder, and where echinites begin to appear, which are not found in the calcareous stone. My nephew estimated that this mass of chalk might be a hundred feet in thickness. On these strata there rests a distinct mass of about two hundred feet in thickness, consisting of strata of whitish chalk, which *in their turn*, form for a considerable space the foot of the cliff, where they all appear in succession, in consequence of their inclination: there is as yet no vestige whatever of flint, and the cornua ammonis disappear in them to such a degree, that, with the greatest attention, my nephew discovered only one,

formations of the chalk itself, produced by some substance precipitated at the same time with it; which circumstance I shall here confine myself to mention

larger, indeed, than all those which he had seen in great number in the first of the preceding strata; it was ten inches in diameter: there are some echinites in those strata, but they are not yet there in considerable number. Finally, on these last strata are found resting beds of common chalk, of a brilliant whiteness, and which, beginning even from the first, abound in flint: they contain many shells, but the general mass of them is very different from what we observe in the preceding strata: that species of chalk still contains many shells which are no longer found in the present sea, such as the belemnites, and the species of echinites, of which the sharp points, in the form of striated clubs, are called Jewish stones. But the cornua ammonis have disappeared; my nephew perceived no trace of them at Beachy-Head, namely, in the mass of that last species of strata which rest immediately on the preceding; I have never seen any in the strata of that chalk which I have examined in various places. Having, however, followed the coast for a space of from twelve to fifteen miles to the S.W., my nephew found on the beach, at the foot of a cliff of that same chalk, the remains of a *Nestor* of that race, which probably had survived it some time; it was a large fragment only, but sufficient to enable us to judge that the entire shell was at the least two feet nine inches in diameter; it was of that species whose last involution covers all the others, in the manner of the nautili. It is not therefore trituration which has occasioned the disappearance of the cornua ammonis in the chalk strata, as those naturalists might imagine who consider the chalks to be the detritus of marine bodies. I do not dwell upon this notion, the error of which is so evident, not only from the perfect preservation of shells quite as fragile as the cornua ammonis, and which are found there in great abundance, but from the accumulation in regular strata, each according to its species, and from the changes of the species themselves.

We see from this instance, the changes which the marine animals underwent, even during the gradual transition from the calcareous stone to the chalk containing flints, which elsewhere differ much more widely from each other; and we also perceive that it was at

only, as I do also with respect to another, which I have proved in the thirteenth of those Letters, and before in my Lettres sur l'Histoire de la Terre et de l'Homme; namely, that all the flinty gravel dispersed in so many places among the loose strata of the surface of our continents, has been formed in chalk strata. Whence it follows, that at the times posterior to the formation of these strata, there happened in certain parts of the liquid, changes which gave it a power of dissolving them, without, however, its having any effect on the flints, which thus remained on the bed of the sea.

29. I think it not necessary to return here to those considerations, which render it evident that the chymical operations through which our globe has arrived at the state in which we now find it, can be assimilated only by general characters to those that we

the period when the precipitation of the substance of the chalk was intermixed with molecules proper for converting it partially into silex, that at length the race of the cornua ammonis, consisting of so many different species, came to be wholly destroyed: a period likewise when, in other places, immediately upon the strata of calcareous stone, were formed the strata of sand-stone, mentioned at the end of the preceding Letter.

[The above note contains the observations of Mr. J. A. de Luc, the younger, on the Sussex coast, made in 1796; observations which were confirmed twenty years afterwards, by the English geologists. They were erroneously ascribed by M. Alex. Brongniart, in his Géologie des Environs de Paris, to our author. At the end of the note, the latter supposes that the race of the ammonites ceased to exist in the chalk containing flints: but since the publication of the work, some ammonites have been found in the chalk beds. See "Geology of England," p. 100, where the authors speak of an ammonite seen above a stratum of flints near Dover.] Ed.

observe to take place at this day. Thus, with regard to the dissolution of the chalk, in the same liquid that produced it, it will be sufficient to observe, that in many known cases, changes almost insensible in a liquid produce this same effect. We must not lose sight of this consideration in the study of geological phenomena; and I entertain no doubt, that through such study, and the progress of observation, we shall be enabled to account for many other particular phenomena that still embarrass us, of which I shall here adduce another instance.

OF ROCK SALT.

30. This phenomenon, so visibly peculiar, has nevertheless (like the phenomenon of volcanos) given birth to geological systems, in which, supposing that there could be no other producing cause of a salt so nearly resembling sea-salt, but the evaporation of a certain quantity of the water of the sea, and finding nevertheless stony strata resting upon, and sometimes interposed between the beds of rock-salt, their framers thought it necessary to assume, that the sea had at various times covered our continents. I have shown, in the twenty-fourth of my Letters in the Journal de Physique, that this idea of the invasion and recession of the sea, is contradicted by all the facts; and there also I have made it evident, that nothing in general chymistry contradicts the supposition, that these salts have been precipitated from the sea itself, owing to some local changes in its liquid. But after this precipitation, there followed others of a different kind,

which produced certain stony strata; and these, after various alternations of the two kinds, in some places, served to protect the strata of salt from the action of the liquid, when, after new precipitations, it had arrived at that state in which it could dissolve them, as would now happen, were they to pass again under the waters of the sea.

31. This phenomenon, then, considered in its general character, belongs to the general causes to which we owe all our strata; and in that particularity, of a change in the liquid, which rendered it capable of dissolving a substance formed in it, it is analogous to the dissolution of the chalky strata, with only this difference, that the latter have left us their flints, whereas nothing in the salt strata could remain to point out those substances which, since their formation, have perhaps been dissolved. Lastly, these alternate strata of rock-salt and stone have undergone, like the beds of coal and fossil peat, the great catastrophes that have taken place at the bottom of the ancient sea, and are accordingly found in those broken masses which form all the eminences on our continents, or extend, in this confused state, under other strata which characterize the following period[1].

SIXTH PERIOD.

32. I fix the commencement of this new period at the time when the greater part of the stony strata,

[1] See Journ. de Physique, Tom. xxxvii. pp. 446—459; xxxviii. pp. 90—109. 174—191.

after having been produced, had already suffered the catastrophes I have described in the preceding periods. The precipitations which continued to take place in the liquid, produced then scarcely any substances capable of forming hard strata, by remaining at the bottom of the sea; these new precipitations were different powders, calcareous, argillaceous, or ferruginous, and also sands. I have proved in my first Letter, that all these strata are, like the former, the immediate productions of the ancient sea. As for the gravels which we find intermixed with them, those of flint proceed, as I have said above, from the strata of chalk that have been dissolved; and those which consist of fragments of stony strata, chiefly primordial, proceed from the revolutions which the bottom of the sea was so frequently undergoing, other instances of which we shall soon come to. I have treated this matter at length in the works quoted above.

33. The strata that mark this period, are then principally those loose strata at the surface of our continents, which are intermixed in so many places with the spoils of marine animals; they accumulated on the stony strata in the disorder in which they already were, except on the mountains, many of which were become islands. We find also, here and there, in the plains, hills formed of stony strata, which, in consequence of various revolutions, are not covered with these loose strata; again, other masses of the stony strata are imbedded in the soil, raising their summits near the surface. These stony masses are in ruins, and their broken strata are inclined in every direction. In sandy countries these rocks are sought for beneath the soil, in order to procure stones

for building. M. de Dolomieu has given us a very interesting instance of this phenomenon with respect to Lower Egypt. In those sands, which he has proved to have been deposited upon all the other strata, before the Nile or any of our rivers existed, there rise here and there calcareous rocks, the strata of which extend beneath the sands; and it is in the neighbourhood of these rocks, as furnishing the materials, that the most ancient cities of that country were built. Now, in following under the soil in many countries, these summits of subterraneous mountains, we find, as in the coal-fields and mines of rock-salt, that the bases of our hills and plains, which are covered with loose strata, are as certainly as the mountains that project outwardly, the ruins of stony strata.

34. These loose strata themselves have undergone divers catastrophes before they were abandoned by the sea; and probably also they suffered at the era of this great revolution. The marks of these catastrophes are the abrupt sides of many of the hills, which present vast sections, the whole of which, or greater or less portions towards the top, consist of loose strata, while all the rest of the soil is depressed below them. When these phenomena, very common in every country, have been attentively considered, we cannot doubt that they are the effects of the last subsidences which the entire mass of the strata has in those places undergone; I have observed them with all their modifications in a variety of countries, and every where it was obvious that they could not be ascribed to any other cause. The loose strata, thus broken, are often much inclined, together with the

stony strata that lie below them; and in numerous places there is found upon them, as well as upon our calcareous mountains, a great abundance of fragments, frequently of an enormous size, of primordial strata, which must have been driven from the inner parts by the violent eruptions of the expansible fluids, during the catastrophes and partial subsidences of the whole mass of strata down to the granite[1].

OF FOSSIL BONES.

35. Another phenomenon, which, in the number of geological monuments, characterizes this period, is the remains of terrestrial animals deposited in the loose strata; the first trace of the existence of these animals on our globe. I have already shown in my first Letter, that this phenomenon is one of those that serve to demonstrate the inconsiderable antiquity of our continents; on adverting to the degree of preservation in which the bodies of these animals are found in strata not very deep, composed of loose materials, and which the rain water is continually pervading to form our springs. When, therefore, we seek to

[1] .... Among the systematic views of M. de Saussure, on which I do not agree with him, is his opinion that the dispersion of the granite blocks and other fragments of primordial stones, was produced by what he terms *débacle*, or the retreat of the sea from the surface of our continents .... I trust that in a future publication, which will contain many new facts, I shall succeed in producing a change in the sentiments of that eminent observer, by connecting the phenomenon of the scattered blocks, not with the *débacle*, but with the overthrow of the strata, on which last point he was my first guide. [See the author's Travels in France, &c.]

determine at what distance of time these bodies were deposited in the places where they are found, we must for the moment forget that we have to speak of the rhinoceros, elephant, and hippopotamus, which at one time existed in our climates, together with kine, deer, and other of our European quadrupeds: this mixture, so surprising, is, without doubt, a great phenomenon, but its cause is not to be sought for in the long lapse of time, as I am going first to call to mind.

36. Those who have fancied that elephants and rhinoceroses have passed southward by a regular course of changes on our globe, have imagined they found this explained by the idea that the globe has gradually cooled, and that the sun having longer maintained its heat between the tropics, these animals, which at first lived to the north, have gradually migrated towards those regions which they now inhabit. But this is quite a gratuitous hypothesis; for since the whole course of the observations of mankind has not served to discover any sign of this cooling of the globe, there is no limit to the time to be assigned for such a change in the temperature; while the state of the preservation of the bodies of which we have been speaking, fixes very narrow limits to the time that has elapsed since these animals existed in our climates.

37. But let us come to the real fact. If there had been a gradual migration of elephants and rhinoceroses from the north to the south, our continents must have themselves existed at the time these animals inhabited our latitudes, since they must have passed from country to country into the regions they now inhabit; and this is what they suppose: but the remains of these animals are found in such strata as

contain also the remains of marine animals; the sea, therefore, as yet covered these countries at the time when these quadrupeds, now foreign to us, were living; which totally contradicts their supposed migration on our continents. There happened then to these terrestrial animals, at this period, what had happened in the preceding period to such quantities of vegetable substances; those which inhabited islands, the mass of which had not yet a solid base, were enveloped in their catastrophes. Some of them saved themselves by swimming to other islands; and they are those that perished in the passage, or those whose bodies which we find buried in our strata, were already deposited in these islands before they sunk below the level of the sea. There has happened then some revolution on our globe, since the time when these animals lived in our latitudes, and it is in this revolution that we shall discover the cause why they no longer live there. This will be explained in the sequel.

38. We must not confound this phenomenon with that of the bones, which are found in such quantities in certain caverns. I had made this mistake in my Letters on the History of the Earth, &c. in describing the cavern of Squartzfeld; but I rectified it in the 14th of my Letters in the Journal de Physique. This latter phenomenon differs essentially from the former, because the bones in question are found buried under an accumulation of stalactites, which shows that they were deposited there at times when these caverns were already above the surface of the sea. I have stated in the same Letter the reasons that lead me to believe that these caverns belonged to islands, which have since become the summits of our hills and moun-

tains, and that they then served as places of retirement to quadrupeds, principally amphibious; which I have exemplified from certain parts of the coast of Scotland, where the same thing still takes place. The sea-cows chiefly retire into caves along the coast, when they are sick, and die there [1]. These ancient caverns were then, as it were, cemeteries for the animals which inhabited or frequented the islands to which they belonged, which alone can account for the prodigious quantity of the bones of animals foreign to the country, which have there been found heaped up and covered with stalactite; and we have proofs that they have not been there for many ages; for those which are not thus covered are in great preservation; and in many of these caverns the progress of the stalactite has been observed by succeeding generations.

39. In thus drawing near to the epoch when the organized beings of our globe, marine as well as terrestrial, arrived at the state in which they now subsist, I ought to premise, that I have not had any intention in these Letters to speak of their origin; it is too important a subject to be treated transitorily: but I shall devote to it an additional Letter, after having completed my observations on what regards the earth itself [2]. I therefore shall confine myself to the remark, conformably to what I have already stated, that the remains of animals, both marine and terrestrial, and of vegetables which we find in the last strata produced by the sea, previously to its retreat from our continents, are almost entirely similar to the species

[1] See Introduction, Sect. V. note.

[2] That Letter forms the seventh of the French edition.—Ed.

now existing, and that the only difference of consequence to be noticed is, the change of latitude in regard to some of the species; a circumstance not peculiar to the terrestrial animals, but which extends to numerous species of marine animals.

40. At length, then, I have arrived, through a series of geological monuments and physical causes, at the end of the sixth of those periods, into which I have divided the chain of operations which commenced from the addition of *light* to the other substances of which the earth is composed; fixing for the end of those periods, on the epoch when the sea was ready to abandon its first bed. I said at my entrance upon this discussion, that these six PERIODS bore a relation to the six DAYS mentioned in the first chapter of Genesis; nevertheless I have not adverted afresh to this idea (excepting in some particular cases) in the course of my exposition, because it is to stand alone. But when well-informed men shall come seriously to attend to the relation that subsists between the circumstances characteristic of each of these days, and what has passed on our globe in the periods corresponding, proved by monuments open to every one's observation, they will acknowledge that nature herself pays homage to that sacred and sublime history, which will receive very striking confirmations in the course of the period in which we live.

41. There is one main circumstance only of which these monuments give no evidence, namely, the appearance of man, in the sixth period; no human skeleton having been found in our strata; but from this we can draw no other geological consequence, independently of the Mosaic narrative, except that

men, if they existed then, had not passed, as the animals and vegetables had, into such islands as were subject to submersion; that they had remained on the ancient continents, and that they were destroyed with them in some succeeding revolution in which those continents suddenly sank, so as that the sea overflowed that portion of the globe, and abandoned its ancient bed, thus become our present continents. This shall be the subject of my next Letter; and when I shall come to point out the astonishing agreement of that catastrophe with the circumstances of the deluge as described by Moses, I shall particularly show that the absence of human reliquiæ from our strata, is in itself a very important phenomenon.

LETTER V.

Birth of our Continents—Proofs of the little distance of that epoch.

Windsor, July 1, 1794.

SIR,

THERE exists no longer any doubt amongst naturalists that at the period of the birth of our continents, they were, and had been, for a long time, the bed of the sea; so that the principal object of geology is to explain, "how the sea, after having been once higher than our continents, comes now to be depressed below them."

1. I have not, in these Letters, reverted to that question, "whether this important change that has happened on the surface of our globe has been produced gradually, or by a sudden revolution," because I have fully discussed it in my Letters on the History of the Earth and of Man, where I have proved, as well in answer to those systems that are founded on gradual causes, as in a general way, that the birth of our continents has not been gradual, but sudden; and this is what has been also admitted by two of the most distinguished geologists of our time, M. de Saussure and M. de Dolomieu. But it remains to

determine the nature of this revolution; and I shall proceed first to cite some facts which clearly point it out.

2. We have seen that the entire mass of our continents is composed of strata, produced by the sea while it occupied this portion of the globe. These strata, which we may every where unequivocally trace, notwithstanding the various accidents they have undergone, extend every where down to the present sea, of which, after this revolution, they constituted the new boundaries. On this account I shall call them continental soil.

3. As soon as the sea had changed its bed, the rivers were formed upon the new continents, and arriving at the sea, began to deposit at their mouths the mud they brought down with them: the sea also, agitating the sand in the more shallow parts, drove it back towards its shores by the action of the currents and tides. From these two causes, new lands began to be formed, which, contiguously to certain parts of the original coast, occupied successively the place of the water. These new lands are every where as distinct from the continental soil, as a layer of sand or gravel in front of a house, is from the house itself; their existence evidently proves that the level of the sea has had no tendency to rise since it has occupied its present bed; for, in this case, it would have successively overflowed either every where, or near certain coasts, the sediments that were deposited on its shores; whereas there are new lands upon every coast, or in its vicinity. If, on the contrary, the sea had had a tendency to sink, the new lands would necessarily have a regular slope towards it, by which we might

be able to measure the quantity of its depression since it occupied its present bed: but all the new lands, on every coast, of whatever extent they may be, are sensibly horizontal. This phenomenon, then, amounts to an absolute demonstration, that the sea has undergone no change in its level since it has occupied its present bed.

4. But before the sea occupied this bed, it covered our continents, and thus existed at a much higher level. What barriers could then retain it? It was impossible they could be other than lands more elevated than itself, which consequently occupied the place where the sea now is, and we know certainly, from the quantity of the remains of vegetables and terrestrial animals, which have been buried in our strata while yet under the sea, that there did at that time exist such lands. Thus, in order that the sea should have retired from the surface of our present continents, other continents, which before served it for a barrier, must necessarily have sunk so as to form the basin which it at present occupies.

5. This is a necessary consequence of the above facts, and its evidence does not depend on our determining how this revolution happened; but we shall soon discover it, by continuing to pursue the train of causes established in my former Letters, of which I shall, in few words, recall to your recollection such parts as the subject requires.

6. The state of disorder in which we find all our strata, could have been produced only by considerable and repeated subsidences of the greater part of their mass, at eras marked by their monuments. These subsidences of the bottom of the ancient sea could

proceed only from the successive formation of caverns within, into which the increasing crust of strata, from time to time, fell down. By this is to be explained that great phenomenon which has given birth to geology, namely, the disappearance, at the exterior, of a great part of the liquid which formerly covered the whole globe, at a level exceeding our highest mountains. We have also found, in this disruption of the caverns, from whence issued, each time, new expansible fluids, the chymical cause of the successive changes in the precipitations that took place in the liquid, as well as of the simultaneous changes undergone by the atmosphere, so visible from the history of vegetables and animals. Lastly, when tracing the course of these operations, I pointed out an epoch at which, whilst the liquid covered the whole globe, a more rapid enlargement of the caverns under one portion of the crust of strata occasioned its sudden depression; by which, added to the infiltration that followed of a great part of the liquid in the interior of the globe, it ceased to cover more than the part which had subsided, which at once formed the first sea, and gave birth to the first continents. Such are the facts I wished to recall to your remembrance; I now proceed with the thread of this history.

7. After this first revolution, the lands produced were for a long time safe from greater catastrophes, owing to their being relieved from the weight of the liquid, which, at the same time, could only make its way beneath them at their borders, which served as the confines of the sea. In the long course of catastrophes that happened to the bottom of that sea, some of the liquid, from time to time, thus passed under

the land: but this infiltration was slow, and in proportion as it produced the subsidence of the mass of pulvicules, concretions continued to be formed in these, which gradually multiplied the props of the crust of the strata, as the cavities increased in size and number beneath it; so that this crust now rested only on a foundation to a great depth cavernous. Such was the state in which the ancient continents were at the period where I left those operations in my last Letter, a state conformable to the progress of the causes which had produced all the effects we may trace up to that time, through a series of characteristic monuments.

8. But at length, by some new catastrophe at the bottom of the sea, directed by Him on whom events depend, a great portion of the liquid suddenly penetrated into the lowest caverns under these lands, and there occasioned a subsidence of the pulvicules, even under the lowest supports, beneath the cavernous mass; this then began to fall in; its demolition gradually extended even to the exterior crust, which, giving way, completed the destruction of all the supports, on which, up to that period, it had rested; and the sea having no longer any barriers, flowed over this portion of the globe, where, in a little time, it settled itself at the level we now find it. Such then was the cause of this revolution, of which, as we have just seen, the nature is pointed out by decisive phenomena; and we shall see it still further characterized by many others.

9. I have said in my preceding Letter, that the last precipitations which took place in the sea, while it occupied its ancient bed, produced our beds of sand

and other loose substances, which cover the ruins of the stony strata on our plains and hills. I will now add, that when the sea had changed its bed, the same operation continued, or was renewed for some time; by which its bottom became covered with a great quantity of sand. This accounts for the close resemblance which exists between what we call the sea-sand, and the sand of so many of our hills and plains; and this is one of the circumstances which prove, as other naturalists have remarked, that the sea once covered all these lands. But this insulated proposition is insufficient: it must be connected with the proofs that result from the great accumulations of shells and other marine bodies, found in so many places in those superficial strata, and with the quantities of the same bodies found buried in some species of strata, while yet covered by the sea. It was not then (as some geologists had thought) by its incursions upon our continents, that the sea covered them with so much sand: it deposited the sand stratum by stratum, during its abode upon them; and it is by some continuation of these last precipitations upon that ancient bed, that it has also covered its new bed with the quantity of sand which we there find [1].

[1] "We must distinguish," observes Mr. J. A. de Luc, the younger, in agreement with the opinion of the author, "between the beds of sand and gravel and rolled pebbles produced by the great revolution, and the quartzose sands dispersed at the surface of so many countries. The first are only the detritus of the rocks of mountains; we have considerable accumulations of them in the basin of Geneva. The quartzose sands are undoubtedly a chymical precipitation of the ancient sea. Such are the sands of the north of Germany, those of the Hebrides, those on the coasts of Senegal, of New Holland, of deserts; these sands are homogeneous, and do not

10. These precipitations of sand put an end to all the great chymical operations which the addition of light to the mass of the other substances of the earth had set in motion; for since that time, no precipitation whatever has taken place in the sea; and this cessation, in consequence of the circumstances which have accompanied it, comes now in support of all that I have said of the series of the great operations which have formerly taken place upon our globe. The level of the sea not having changed since its residence in its new bed, is a proof that no more great caverns

proceed from the detritus of rocks. Notwithstanding, it must sometimes happen that those two kinds of sand are intermixed according to the localities. Thus in the north of Germany, and in the eastern provinces of Holland, the quartzose sand of the *Geest* is mixed with fragments of primordial stones and flints; these fragments are often reduced into sand, especially the micaceous rocks. When De Luc says, Letter V. §. 9. that the sea has deposited the sand stratum by stratum, while it yet remained on our continents, he speaks of the quartzose sand. At Husum, and along a considerable part of the Elbe, the continental soil has the name of *geest*, in order to distinguish it from that of the new lands on the coast, which is called *marsch*." See Geol. Trav. vol. i. §. 381.

In the same manner that we can distinguish two sorts of sand, we may likewise distinguish two sorts of gravel; the first consists of the flints which have been liberated in consequence of the dissolution of the chalk,—and also of gravels which have proceeded from other rocks, and have been dispersed over the bottom of the ancient sea; the second sort was produced by the currents of the ocean when it changed its bed, or at the period of the last revolution. Mr. J. A. de Luc further observes, that the beds of marl in Piedmont enclose different beds of marine shells, and that, when traversing the province of Asti, he found no rolled pebbles in them. He considers it probable that those marls are a precipitation from the sea, for he was unable to discover any rocks of which they could be the detritus. —Ed.

have been opened within it, from which the liquid, in the act of absorption, caused new expansible fluids to issue forth. Now such is the reason that the liquid that remained at the exterior no longer parts with any of the ingredients which it still retains, for it could do so only by some new chymical cause; and in the present state of rest of the mass of the globe, there exists no longer any cause of fresh precipitations. Thus the present water of the sea is the residue, hitherto unchanged, of the liquid, which at one time covered all the globe, and from which were separated all the substances which constitute our present lands; and by this state of rest, at which the great agents of the operations that have taken place on our globe have at length arrived, its atmosphere, one of the products of these chymical operations, has acquired at the same time, a state sensibly fixed: so that we no longer see on our globe any other general effects than such as proceed from the vicissitudes of the seasons, and the reciprocal actions constantly taking place between the atmosphere and its basis, namely, waters and the surface of different soils[1].

11. I have now, Sir, accomplished the task I set myself in my first Letter, that of explaining, by physical causes, all the monuments of the great revolutions that we find on the surface of our globe. General physics, chymistry, and natural history, have served to conduct me through these monuments, from a very striking epoch, namely, that in which light was added to the other elements of the earth, to the birth of our present continents, the characters of which, at this day

[1] For further details on this part of the subject, see Journ. de Physique, tom. xxxviii. pp. 275—288; tom. xli. (part ii.) pp. 221—227.—Ed.

well determined, have served me as guides in this research. I have called that series of events *the ancient history of the earth,* in which we distinguish only a succession of periods, without any determination of time, because we can discover there general causes only, acting according to certain circumstances, indicated indeed by the phenomena, but which no longer exist, and of which, consequently, we cannot compare the effects with time. The scene is now about to change; and I shall therefore call that the *modern history* which I am now going to enter upon, in which we shall find every thing that a fixed chronology requires.

HISTORY OF THE EARTH SINCE THE BIRTH OF OUR CONTINENTS.

12. The two first objects we have to consider in this new period of our globe, are, the change that took place in its external temperature at the time of the revolution I have been describing, and the origin of the population of the new continents. With respect to the first, we have to recollect, that the rays of the sun are not of themselves calorific; that they do not become so with regard to the earth, but by passing through its atmosphere, and falling on different bodies, and by their being there so modified as to produce the immediate cause of heat, which, with all naturalists, I have called fire. We also know, that the production of fire by the rays of the sun, is, *cœteris paribus,* more or less abundant, according to the state of the atmosphere, and of the several bodies; and that the permanence of the igneous fluid, whether free or combined with other substances, and consequently the preserva-

tion of the heat produced by the rays of the sun, depend on the nature of the operations that take place in the atmosphere, and at the surface of the soil. Now, our atmosphere was formed by degrees, in proportion as the substances of our strata were precipitated in the liquid that produced them; and we see that it underwent successive changes, by what happened to the vegetables of the earth, at the same time that the races of marine animals also suffered changes by corresponding modifications of the liquid of the sea. Lastly, we have seen, that these two classes of changes had, for an immediate cause, certain successive revolutions of the bottom of that liquid. Here, then, is the point I shall set out from, to determine the first object of enquiry in this new state of the earth; namely, a great change of temperature in the regions without the tropics, in consequence of which, animals living there before that revolution, as is rendered evident by the quantity of their carcases found in our superficial strata, could no longer exist in them.

13. Since the great revolution which gave birth to the first lands on our globe, there has been none equally considerable, except that which destroyed those lands, and gave birth to our present continents. The atmosphere must have again undergone a great change in this latter revolution. There happened certainly at that time also a very great change in the dry surface of our globe; since the lands that were swallowed up consisted only of primordial strata: whereas the new continents have at their surface, and to a great depth, all the posterior strata; so that the primordial beds appear only here and there, owing to convulsions undergone by the whole mass of strata.

Lastly, after the precipitation of sand upon its ancient bed, the sea itself was no longer the same compound, and the nature of its exhalations was changed.

14. Here, then, are two very great changes which have taken place on our globe at the birth of our continents, and from these may have resulted very sensible modifications of the influence of the solar rays, not only with regard to heat, but with respect to all their operations. Without doubt we could not conclude from these, arguing *à priori*, that certain animals, which formerly lived without the tropics, could live there no longer in the new state of things; for we are still too ignorant of the composition of the atmosphere to trace its causes and effects to this depth: but, finding in our superficial loose strata carcases of elephants and rhinoceroses in such a state of preservation as proves they cannot have been deposited there a great number of ages, we are led to the general conclusion, that not very long ago a great change must have taken place in the physical causes operating at the earth's surface, subsequently to which those animals have ceased to exist in the regions which they previously could occupy. We know in general, in this respect, that differences in the state of the atmosphere, as well as in the nature of soils, sensibly modify the action of the rays of the sun, whether with regard to the production of heat, or the duration of the heat produced. Accordingly, permanent changes of this kind may have produced the great actual difference between the temperatures of winters and summers, and even between the days and nights in our regions [1]. Naturalists had

[1] "Previously to the birth of our continents," says the author, "the same animals, marine as well as terrestrial, lived equally in all

contented themselves with assigning as causes of these differences those of the positions of the sun; because the intermediate causes by which its rays produce heat had not hitherto been considered; but although those causes are not as yet well defined, they are, notwithstanding, at this day, admitted by all observant philosophers. Now those intermediate causes may formerly have been such, as constantly and more completely to produce what we observe to a certain degree in the actual state of the globe; namely, that external heat results only as a secondary effect, greatly modified by intermediate causes, from the different positions of the sun; insomuch that in our regions, the nights are often as hot as the days which precede or follow them, —that mild winters precede or follow cool summers; and that these modifications differ in different coun-

latitudes; for in every latitude we find in our superficial strata, particular kinds of marine and amphibious animals, such as the great pearl nautilus, and the hippopotamus, (which at present live only between the tropics), as in like manner we discover in them the carcases of the elephant and the rhinoceros. Doubtless at that period the atmosphere was such, that by a longer preservation of the calorific effects produced in it by the solar rays, the heat was much more equal at the earth's surface. Whoever has noticed the great differences which sometimes occur even in the present state of the globe, in the temperature of the winters in northern regions, without our being able to assign a cause for them, will not refuse to admit the inference which those facts necessarily seem to require, and respecting which geology supplies us with general views, namely, that before our continents were abandoned by the waters of the sea, the temperature was considerably higher at the surface of the earth than at present."—See the Author's "Remarques sur l'Origine des Etres organisés," a dissertation forming the seventh Letter of the French Edition of this work. Ed.

tries at the same latitude. It is, therefore, very natural to conclude, that previously to that revolution of the globe which gave birth to our lands, the respective states of the atmosphere, of the sea, and of the soil was such, that the differences of the external heat were not so great between the different latitudes; and that in our regions its vicissitudes, from day to night, and from summer to winter, were less considerable than they are at present; which sufficiently accounts for some species of animals living in those regions formerly, which at this day can exist only in latitudes where the sun renews more constantly its productive effect of heat. Lastly, a circumstance immediately proving that at the time when our lands were abandoned by the waters of the sea, some change of this nature occurred in the physical causes which act upon the globe, is, that this revolution has affected not only some species of terrestrial, but different kinds of marine animals. For we likewise find, in our superficial loose strata, some shells of a race that was destroyed by the same revolution, and of others which since that time have been found to exist only between the tropics. Thus these phenomena of the organized beings on our globe, inexplicable by means of every slow cause, and which thus announce a great revolution at some determined epoch, are accounted for through the intervention of particular physical causes of a known kind, by the same revolution which we have already seen characterized by so many other phenomena.

15. The other object we have to settle, before we enter on the history of the new continents, is, the commencement of their population. In treating of

that subject in this place, I do not mean to specify any thing either with respect to man, domestic animals, or even the greater part of cultivated plants; I shall come to this hereafter: at present I have nothing in view but the general object.

16. We have seen already, that in numerous parts of the ancient sea, not near the coasts only, but throughout its whole extent, the strata which it produced successively enveloped carcases of terrestrial animals, and, above all, a prodigious quantity of vegetable substances, which could proceed only from a great number of islands, already peopled, the origin of which I have also explained, and whose history I have traced. A number of similar islands still remained in that sea, up to its retreat; and as it retired to a lower bed, those islands, covered with plants, and peopled with animals, became the summits of our mountains. The winds and rains transported from thence the seeds of plants to lower lands,—birds, and other animals assisting, and these spread as their nourishment increased, on the hills and plains, wherever in the new state of things, the climate suited them. Such is the general source of the population of our continents, of which we shall see successively the proofs.

17. I have already stated that the history of the new lands, subjected, as soon as they were dry, to the influence of those causes which are at present operating before our eyes, had a progress truly chronological in all its parts; and this I will now further say, (without as yet entering into the detailed examination of the connections of the revolution of which I have just established the existence and the characters, with the

circumstances of the deluge described by Moses,) the common result of the several investigations I am going into, will in the first place be a confirmation of the sacred chronology since this event.

18. As the first object in this enquiry, I shall advert to the history of vegetation, which alone comprises a field of great variety. The seeds of mosses, grasses, heath, and a thousand other plants, which we find growing in uncultivated lands, were transported from the loftier spots, and carried over all the hills and plains; and the vast extent of sandy grounds became thus almost every where what we now call heaths. It is of this kind of uncultivated land I shall first treat. The annual remains of plants accumulating on the sands, and other soils immediately favourable to vegetation, began to cover them with that blackish earth (humus), in which we find the present plants rooted. There are immense tracts of these lands which have yet received no cultivation, and on which, therefore, the stratum of blackish soil is the entire residue of all the vegetables which have grown and perished there since the birth of our continents. In places too far from every habitation, for even the shepherds to lead their flocks to, and where the heath alone vegetates, at whatever elevation such spots are above the level of the sea, this blackish stratum is found (always mixed with a fine sand brought from other places by strong winds) about a foot and a half in thickness. Now the progress of this stratum is accompanied in many places with chronological monuments, and I shall describe one of those I have mentioned, in treating this subject much at large, in my "Lettres sur l'Histoire de la Terre, &c."

19. The first inhabitants of the north of Germany were shepherds, who, as yet, had no fixed habitations; so that the only monuments remaining of them are their tombs: they deposited the ashes of their dead in urns, which they buried in open places, principally on the heights, and covered them with earth. We find a number of these tombs on hills still uncultivated: they are well known under the name of tumuli, which, I suppose, they received from the Romans, as they are nothing more than heaps of earth. Here, then, the anterior product of vegetation was removed; what has formed there since, is the product of the subsequent vegetation; and this epoch is marked by the history of the ancient Germans, who, after the invasion of Germanicus, began to collect together, and build. I have dug through the blackish stratum on a number of these tumuli, for the purpose of comparing its thickness with that of the general stratum of the rest of the ground; and considering the small difference found between them, we could not find by any means a sufficient time to correspond with the literal Hebrew chronology from the deluge, which certain commentators have seen reason to lengthen. But here we are to consider, that before a layer of blackish mould could be formed, it was necessary that vegetation should be fully established on those lands; and the portion of time that elapsed till then, and which should be added to the result of immediate observation, is not easily ascertainable. The same uncertainty prevails in the commencement of all the phenomena that prove the great truth which I here propose to establish; but from the nature of the specific causes which produce such uncertainty in each particular phenomenon, it will be found, that

though there hence results a certain latitude in the determination of the time total, it is confined within such limits, that this natural basis of chronology effectually opposes, not only all the fables or systems of chronology which are not founded on the book of Genesis, but even the conjectures of some chronologists who have arbitrarily lengthened the period of time between Noah and Abraham.

20. The same result is supplied by the progress of cultivation. Every where, as we ascend in the history of any settled nation, we find agriculture established, and we can follow uninterrupted traces of new cultivation; while at the same time it is to be inferred from the relations of travellers, that one-half of our continents still remains uncultivated. Certain spots of ground, which had something attractive in them, either on account of the facility of tillage, or as offering an easy communication with other places already cultivated, became the cradles of great nations; and in such the traces of the progress of cultivation are not distinctly observable: but from thence have issued vast bodies of men, wanderers at first, afterwards cultivators; whence have resulted a number of centres of cultivation scattered here and there in the first deserts, and which from that time have not ceased, both to increase in extent, and to send out fresh colonies. This process is continued round places adjoining to lands still uncultivated, nor does it appear as if it would speedily terminate. Here, then, is a new succession of operations, which have sprung from the birth of our continents; and in comparing my own observations on this head with those of other travellers, I have had occasion to remark, that the progress of cultivation has left such evident traces in spots

similar to those just described, that when we attentively consider this subject, the aspect of the country, the names of places, the traces of their aggrandizement, their relations to each other in language, opinions, customs, the beginnings of public works by the increase of wealth, the national progress of the arts, commerce, and luxury: in a word, every thing, in a retrospective research, leads us, from every point, to some chief places, the history or traditions relating to which carry us back to the first eras of the cultivation of our lands. This is a most interesting subject, as may be seen by following what I have related at large from observation in my " Lettres sur l'Histoire de la Terre, &c." where I have at the same time pointed out both the moral and physical causes, which accelerate or retard the general tendency we may observe both in the operation of spontaneous causes, and in the industry of man, to augment the products of the ground: and the same remarks have occurred to Messrs. de Saussure, de Dolomieu, and Ramond de Charbonière.

21. It is not then in capital cities, nor in the midst of countries covered with the marks of ancient cultivation, that the history of the human race inhabiting our continents ought to have been investigated; since the traces of succession being there effaced, an unlimited range is left to the imagination; but in those numerous places, where human industry is still at work, forced by the necessities of an increasing population, to augment the means of subsistence by extending cultivation. The history of the cultivators of our land thus evidenced, then comes in as a support to those facts that relate to spontaneous vegetation,

to set aside the fabulous pretensions of some nations to antiquity: since it follows equally from both, that our continents themselves, can have no higher date than the deluge described by Moses. But these again are proofs which require a great assemblage of facts, connected with the history of mankind by questionable links, and which demand much consideration; I shall therefore come to other proofs which will demonstrate the truth of that history of vegetation and culture by indisputable characters.

22. Without yet quitting the history of vegetation, we shall find a new chronometer in our peat-grounds, a phenomenon which I have also described at large in my earliest work. Peat, as well as the blackish earth I have spoken of above, is a product of vegetation; but the remains of the vegetables that form it, lose much less of their bulk, and they retain their combustible property. These vegetables, at first simply withered, form a spongy mass, always saturated with water, and on which new plants, some of them aquatic, grow in great abundance, and with much rapidity. It is, perhaps, owing to an antiseptic quality in some of these plants, that there happens such an accumulation of their remains, constantly penetrated with water, without their undergoing putrefaction; a circumstance that essentially distinguishes our peat-lands from marshes, inasmuch as the air is always salubrious in the former.

23. The formation of peat could commence only with all the other phenomena to which the birth of our continents gave rise: it at first began to form in spots of ground that were watered by springs; and in these places, very favourable to all sorts of vege-

tation, there grew at first trees of a resinous nature, principally pines and yews, the leaves and smaller branches of which, though falling on a humid ground, resisted putrefaction; herbaceous plants at the same time grew on these soils, and began to form peat there. In proportion as this peat became thicker, the new trees took root in its mass, and attained such size, that at length the winds had the power to tear them up, and the peat continuing to increase, buried them. Here is a first period marked in all our large peat lands; for when they come to cut peat to a certain depth, they find the trunks, branches, and roots of these trees; and from that time trees no longer grew at the surface of most of those soils.

24. The peat continuing to increase, frequently extended itself beyond the places where it originally began to be formed; if it was on hills, it descended down their sides; if in the low grounds, it gradually spread beyond its first limits, and sometimes even ascended the slopes of the hills. Every where, in a word, where this spongy substance, in whatever direction it spreads, meets with small springs to moisten it, it continues to increase both in thickness and extent, and where it is not too much softened by the water, trees continue to grow on it. This increase of the peat still continues wherever the circumstances are favourable to it, and where no means are employed to arrest it: we know its progress by tradition; and when we compare it with the mass produced, we discover various proofs of the small antiquity of that phenomenon, as will now appear.

25. In a number of places, where the population has so far increased, that colonies have reached the

confines of large peat lands, they have laboured to stop their progress, and to render their surfaces fit for cultivation; a double end, which is to be gained by first draining the peat, that is to say, by cutting trenches in a direction towards some lower ground where the water may run off, and deepening them as the peat sinks down. Now, in the course of these observations, monuments have in various places been discovered which connect themselves with the history of nations, and of the arts, or with some local traditions, of which I shall give some instances.

26. In draining the great peat lands of the country of Groningen, some Roman medals have been found at the bottom of a trench, buried in the natural soil, since covered with a considerable bed of peat. Here then is a fixed period in the increase of these peat lands, namely, the invasion of the Romans; and this monument is connected with another, on the same coasts, furnished also by a progressive operation, but totally of another kind. Roman medals have been found near the ancient mouth of a branch of the Rhine, which formerly passed through Holland. The Romans had built near this mouth—at this day entirely obstructed by the sands—a custom-house, the ruins of which we discover buried in those sands; and together with the Roman medals, coins of the ancient nations of those coasts have also been discovered.

27. In my travels along these maritime districts, where I particularly observed several great tracts of peat land, I arrived at the country of Bremen, at a time when the inhabitants were carrying on with great vigour the operations of draining, and bringing into

cultivation a considerable extent of peat-land, which is called the Devil's Moor, on account of the accidents that frequently happened to the cattle which ventured on it, as well as to men, who were sometimes swallowed up in it, without the least traces remaining outwardly. The undertaking to drain such a peat-land as this, was too great for the neighbouring peasants; it was therefore carried on at the expense of the Sovereign, who interests himself, with paternal attention, in every thing relating to their prosperity. During this operation, they discovered at the bottom of a deep trench, an ancient aqueduct, formed in the sand with planks, near which they also found an auger to bore wood with, which they showed me, and which is very similar to ours. Now, the depth at which were found those monuments of art, belonging to a time the moderate distance of which we shall see, bore a very considerable proportion to the total depth of the peat on its original base, which is sand, by which also all the surrounding hills are covered.

28. At a period not very far distant, for they already spoke the German language in the country of Bremen, the Devil's Moor was still here and there studded with small sand hills, which had all their several names, with the termination *berg*, which signifies an eminence. From that time, though the peat, in continuing to rise, has covered these eminences, the places where they had been noticed by preceding generations, have retained the same names, with the termination *berg*. This circumstance has been attended with most fortunate effects; for, without the tradition connected with it, these solid places in the peat-bed would have been unknown; and wherever

they are not too far from the borders, they are very useful spots for building new villages. When the peat is drained to a considerable depth, it sinks down; it is then cut for fuel on those solid spots where it remains higher than in the neighbouring places; and while those spots afford a firmer foundation for the settlements of the colonists, the latter have still further the advantage of finding there sand at a small depth, which is of great use to them for repairing their roads, and for mixing with the peat at the surface, which adapts it for every agricultural purpose, and even for plantation. The greatest depth of the peat-bed, through its whole extent, is about 35 feet; it was still sprinkled with islands, or small eminences of sand, at a time when the German language was the language of the country, and when the inhabitants determined the direction of the waters in the sand by the same means, and with the same instruments as our own; and in growing to its present thickness, the peat has entirely covered these eminences. This then is a phenomenon not very slow in its progress, and its origin is to be dated from the birth of our continents. Thus the history of peat-lands traced, in their formation, by causes that could exist only with our continents, and, in their progress, by historical monuments of different kinds, would be alone sufficient to confirm the chronology of the sacred history since the deluge.

29. Let us now change the scene;—for all progressive phenomena, of whatever kind they may be, if they had necessarily their beginning at the birth of our continents, ought to furnish us, as they do in fact, with the same chronological scale. I have

already pointed out in this Letter the causes that have co-operated in producing the new lands added to our coasts; and as at the outset of my inquiries into the antiquity of our continents, this phenomenon appeared to me one of the most decisive chronometers we could find, I considered it with much attention; and I have also treated of it at large in my Lettres sur l'Histoire de la Terre, &c. These additions to our continents, by their constant level, and the nature of their materials, are every where distinguishable from what I have called above (§ 2.) continental soil. That distinction is observable at the point of exterior junction; and in digging through the former to sink wells, the original soil, on which the new lands are formed, is found, into which the springs extend that proceed from the continental strata. The origin of these new lands dates from the time when the rivers began to carry down mud to the sea, and the sea to drive the sand from its bottom towards its new shores. The entire effect of these causes is visible; the greater part of the inhabited coasts furnish chronological monuments connected with the progress of their effects, and they continue still to operate on many shores: so that these new lands are true hour-glasses, pointing out the time when the sands and mud began to accumulate. Facts of this sort are very numerous, but here I shall confine myself to one only.

30. The new lands do not become fertile, till in consequence of fresh sediments being left at their surface by repeated inundations, they cease to be often covered by the sea; they then generally become good pasture-land. The inhabitants of the borders of the continental land, in the country of

Groningen and the adjacent territory of Friesland, contented themselves for a long time with making use of the new lands along their coast, only in the summer season: they made hay from them, and then left their cattle to pasture there; but they were obliged in autumn to house them in stables built on small artificial eminences, many of which still remain; because, from this season to the spring, the sea and the rivers frequently overflowed these pasture-grounds. But at each inundation the ground was raised by new sediments; so that at length a great extent of their new lands near the continent was but very seldom inundated. It was, however, some time before these two provinces thought of enclosing this ground with dikes, to secure it from the inundations, which from time to time recurred, and thus to take entire possession of a rich soil, which was proper for all sorts of cultivation. A Spanish governor, whose name was Gaspard Roblez, at length urged them to the undertaking, and the work was completed in the year 1570, of our era, which considerably augmented the habitable ground of these provinces. A great extent of new lands was, upon that occasion, left without the dikes, which yet remained subject too frequently to inundations; and of these they continued to make use, as they had, for many centuries, of the space which was then enclosed. But these exterior grounds continued to receive, at each inundation, fresh sediments which raised their surface; the inundation of these grounds gradually became more rare, and at length ceased sometimes for many years; so that in 1670, a second range of dikes in the two provinces was raised, in order to enclose a fresh belt of ground of the same breadth as the former,

still leaving without them, all such portions of the still increasing new lands as were too often liable to be overflowed; thus giving it time to be raised by the sediments of future inundations. But from that time these lands, continuing to extend, separated into many slips of ground, or different projections, and there was no longer any prospect of other than partial enclosures, which would be more expensive in proportion to the land obtained; and the keeping up of which would have become burthensome to the state. This determined the two provinces to give up the property of the newly recovered ground, present and future, to the possessors of the interior ground along the dikes, to be disposed of at their pleasure. From that time new enclosures have been made there, and these additions continue, but with less regularity.

31. This phenomenon being the effect of natural causes, common to all the shores of our continents where circumstances are the same, and the level of all the new-formed lands having also one common limit, namely, the height of the greatest tides, there can be no difference among them but in their size, which depends on the quantity of matters deposited on the coast, and inversely in proportion to the original depth of the sea in that spot; but their respective progress, marked by particular epochs, have a relation with each other in respect to time, of which I am going to give an instance from another observer, at a rate more rapid than the preceding.

32. M. de Dolomieu, struck as I was with the number of phenomena that prove the small antiquity of our continents, has combated, among others, the mistake of those who have thought they found proofs

of the contrary on our coasts. In his Memoir on Egypt, he took occasion to show the absurdity of all that has been said of the pretended works of the Nile for thousands of ages; and, in order to bring the matter more home to European observers, he takes for an example the present course of the Po, in Lombardy; first marking, by indubitable characters, the limits of the continental soil, that is, the place where the Po first arrived at the Adriatic Gulf, and where the new lands began to form; after which he continues thus: (Journ. de Physique, Jan. 1793.) "In considering the progress of these new lands, from the dates furnished by history, it is impossible to think, that it has required a very great number of ages to accomplish the filling up of all that part of the gulf which at first was vacant, and which the sediments of the rivers have choaked up .... If at the time of Strabo, that is to say, at the commencement of our era, an arm of the sea extended as far as Padua—if a few preceding ages (as Strabo reports) could have added ninety stadia to the continent, and by this means reduced the town of Spina, celebrated for its port and commerce, to the state of a mere village ...... if we recollect that the Salines of Ponte Longo, at present many miles within land, were, only five centuries ago, the subject of a sanguinary war, it is easy to prove that a great many centuries have not been required for the formation of the new lands, which have given such an extent to the plain of Lombardy."

33. This, then, is the true account of these additions to our continents, vaguely referred to by the advocates of the opinion, that our continents have been formed by some slow cause; for we see, upon examining them,

which surely ought to have been done before a judgment was pronounced, that they serve to prove, on the contrary, that our continents owe their birth to one single revolution, not very many centuries distant. The natural standard of chronology afforded by these new lands, all around our coasts, would be too short even for answering the Hebrew chronology, without any of the commentaries which lengthened it, if we were not to consider, that a portion of time was employed in raising the bottom of the sea near the coasts to the level of the water. This I have considered in my first Geological Letters, and pointed out the latitude it may admit in the determination of that chronometer. I shall now proceed to show, that the same result is found in regard to time, by following another class of phenomena, which, quite as vaguely described as the preceding, had given rise to a system contrary to that which I have mentioned above; the system that our continents are slowly destroyed by the attacks of the sea.

34. Along the same coasts, where new lands are formed, we also meet with steep cliffs, against which the sea has exercised, and in many places still exercises, a destructive action. I shall here say nothing of the rocky coasts, because in them we discover no effect of the sea: these rocks are mostly covered with sea-weeds and shells, a proof that the sea has no sensible effect upon them. I shall then speak only of those steep coasts which are subject to crumble down from the visible effect of external causes. These places were at first, either narrow capes, which opposed themselves to the currents and waves of the sea, or steep cliffs, which became such at the period of the

revolution; owing to the same cause that has produced so many sections in the interior parts of our continents, namely, the subsidence of the rest of the strata. I shall now proceed to explain what have been the consequences of that original state of some parts of the coasts, and how the action of the sea every where terminates.

35. All the points of land which opposed the course of the waves and currents of the sea, were attacked by them, and all the original cliffs began to crumble down: but the sea carried the minute materials along the shores, and deposited them in all the creeks and small bays, the beds of which were accordingly raised, and gradually filled up, at the same time that the larger materials collected at the feet of the cliffs (whether new or original) began to form a strand. As soon as this strand appears at low tide along any cliff, the mud brought by the high tides and by the waves, and the materials continuing to fall from the cliffs, gradually raise it, so that at last the sea can no longer reach the feet of these cliffs: these, however, continue for some time to crumble down from the action of external causes; but as all their rubbish then remains at their feet, they are gradually reduced to an uniform slope, and vegetation fixes them in that form.

36. Such is indisputably the end of all these pretended demolitions of our continents. They are nothing more than the action of the sea, aided by external causes, operating to smooth down its shores, and lessen the inflexions of its coasts, by demolishing every thing that at first opposed the free course of its waves and currents; and never do any of the materials, whether carried down by streams, or detached

from the coasts, take, nor indeed can they take, their direction towards the bottom of the sea; for all its different actions, its currents, waves, and tides, have a direct tendency to propel those materials towards the coasts, and to fill up its sinuosities; this is generally acknowledged by all those who have studiously observed the operations that take place on the borders of the sea. The continuance of these operations depends on local circumstances; but as soon as by the united actions of external causes, and of the sea, a strand comes to be formed which has only an easy slope and insensible windings, the sea produces there no further effect. I have followed this operation on several coasts; I have seen it terminated in various places, and in others more or less distant from its termination, owing to some local circumstances which it was easy to find out, and I could always judge from these, in what manner this termination would take place. I have entered into the details of these observations, in my Lettres sur l'Histoire de la Terre, &c. We find also in this class of progressive effects many chronological monuments, and they agree with those we have just noticed in the new lands; a circumstance that shows with what levity theorists formerly struck out geological systems, to contradict the sacred chronology: systems equally destitude of foundation, and contradictory to each other: while the very facts upon which they appeared to dwell, confirm that chronology in the most evident manner; for these simultaneous operations of losses from the coasts in some places, and acquisitions in others, sometimes distant, but often adjoining, prove at once, both that the sea

is in a new bed, and that it has not occupied it many centuries.

37. Every thing that has passed, and still passes in the internal parts of our continents, corresponds with what we find to happen on their coasts, and results from their original state: for demolitions also take place, and new lands are formed, which, in the same manner, come to an end by fixed causes. But before we proceed to these operations, I shall mention a phenomenon, which, by concurring with them to establish the general proposition of the small antiquity of our continents, will directly serve to prove that the sea, at their birth, passed suddenly into a basin lower than its preceding bed. When determining the state of the earth, immediately before this epoch, at which time consequently the sea was still at a high level, I have observed, that the higher parts of our mountains were islands in it; which connects itself with the whole of the geological system hitherto established. Now, I am about to prove that particular consequence by means of a phenomenon, which will at the same time indicate that this change took place not many ages ago.

38. The level of the sea, at whatever elevation it may be, is the sensible base of the atmosphere, and, all things else being equal, it is also the warmest part of it; for the heat diminishes from below upwards. At the time when the summits of our mountains formed islands in the sea, at that period more elevated, these islands were in the lower region of the atmosphere, where they enjoyed a temperature favourable to all sorts of vegetation. But when the sea sank to its

present level, the atmosphere sinking with it, these same lands became situated in a colder region of the air; so that on some of the highest of them, at every latitude, on those for instance, which have become the summits of the Alps, the Pyrenees, and the Andes, there began to accumulate annual remains of snow, which through alternate changes of thaw and frost, were converted into a porous ice.

39. If these masses of ice had arrived at their maximum, they would afford us no indication respecting the time of their commencement, nor consequently respecting its cause: but if they are still sensibly increasing, they must have originated in some revolution of the globe which changes the temperature of the air at this level; and this alteration must have been the less ancient, in proportion to the greater rapidity of the progress which the ice is observed to have made. Now the extent of these ice-fields so sensibly increases, that the life of a man, a chamois-hunter, for instance, is sufficient for him to observe the progress of it, insomuch that generations transmit from one to another the dates when certain spots began to be covered with permanent ice, and when certain passages, existing before, have been obstructed by its progress. This circumstance will not permit us to carry its origin back to a very remote epoch.

40. M. de Saussure, to whom the Alps are so familiar, and from whom we have received so much important information concerning them, has proved, that the whole mass of their ice has a tendency to descend along the declivities, and that this is the cause of the crevices that cross it, as well as of the changes of width and place observable in those divisions of

the mass. These crevices are at first formed in the higher parts of the declivity, from the tendency of the ice to descend; they open when the inferior mass alone slides down the declivity, and close as the higher mass descends to follow the former. If it were not for this migration of the ice, its increase in extent would be much more rapid: but owing to this, it diminishes considerably; either by arriving at certain precipices, where it breaks and falls into some valley below, or by reaching these valleys through some opening in the rocks, where it melts more rapidly. It is those accumulations of ice, descending slowly like lavas, that are called glaciers. There often fall, on the upper parts of the ice, blocks of granite, detached from the surrounding rocks, and these blocks, being carried down by the ice, at length arrive with it in the valley below, where they are left as it melts. Now, the following are the remarks of M. de Saussure on this subject, in reference to the Glacier des Bois, in the valley of Chamouni, but which may be considered as of general application: "The blocks of stone with which the bottom of this glacier is loaded, lead," he says, "to an important reflection. When we consider their number, and come to think that they are deposited at this extremity of the glacier in proportion as the ice melts, we are astonished that there is not a more considerable heap: and this observation, which agrees with many others that I shall report in succession, induces us to believe, with Mr. De Luc, that the present state of our globe is not so ancient as some philosophers have supposed it to be."—Voyages dans les Alpes, section 625.

41. Before we quit this subject of the ice, I will

mention another phenomenon, which, while it furnishes us with the same chronological base, will connect itself with the disappearance of the elephant and the rhinoceros from our regions, as proceeding from the same cause. This cause is a change in the atmosphere, the sea and the soils, in consequence of the revolution which gave birth to our continents, and after which, the heat produced at the earth's surface by the solar rays, was less retained there, and thus not having time sufficient to distribute itself so equably, the temperatures of the seasons and of the different parts of the day became more dependent on the positions of the sun. Then, accordingly, the countries without the tropics, and above all, the polar regions, had, together with very warm summers, winters more or less cold; a circumstance sufficient to produce by degrees the extinction, in those regions, not only of some races of animals, but of vegetables, in regard to which cold is more destructive, than a considerable heat is necessary. It then likewise happened, owing to the same cause, that during the long deprivation of solar heat sustained by the polar regions, the heat so sensibly diminished as to admit of the formation of ice at the surface of the sea, by the union of the particles of water with each other, and their separation from the salt. Considerable accumulations of ice took place at each succeeding winter, the summer heat not being sufficiently great to dissolve it entirely; and the more there remained after each summer, the larger was the quantity formed in subsequent winters, attended by an increase of the former ice; because a portion of the summer heat, instead of communicating

warmth to the water, served only to dissolve the ice; a circumstance which, as is well known, divests the fire engaged in that process of the power of contributing to the heat. If such is the change produced by the revolution which gave birth to our continents, and if that epoch is not very remote, the ice must sensibly increase in the seas of the polar regions; now this fact is ascertained by navigators in the North Sea. The following is Sir Charles Blagden's remark on this subject. (Phil. Trans. Vol. LXXIV. p. 231): "Since our navigation northward, the eastern coast of Greenland, and the surrounding sea, are gradually become more and more inaccessible, owing to the augmentation of the ice." It thus appears, as I have already had occasion to remark, that all the phenomena, of whatever kind, which agree in the common circumstance of having had their commencement at the birth of our continents, and of being susceptible of a sensible progress, prove also in common, that the period of that event is not very remote: and we at the same time find in this last phenomenon, the confirmation of the cause which I have assigned for the disappearance of the elephant and the rhinoceros from our climates. But I proceed to the consideration of other chronometers.

42. I have stated above, that there are relations of origins and causes in the progressive changes observed on our coasts and in the interior parts of the land; their common origin is the state in which our continents were at their birth, and their common causes are gravity and the action of running waters. We may easily represent to ourselves the state in

which the surface of our continents was at the period at which they were abandoned by the waters of the ocean; for, notwithstanding the operations that tend continually to soften down their abrupt faces, we find traces of them every where. Without even going out of towns, or houses, the landscapes with which so many apartments are decorated, suffice to give a very just idea of the phenomenon I speak of; for, should the painter not have worked immediately from nature, his imagination at least will have taken her for a model; and a great part of the picturesque effect of this kind of paintings, consists in high mountains rising in pinnacles, one above the other, and in steep rocks, which exhibit the chaotic state of their strata over more smiling tracts, covered with verdure and woods. In a word, the most common landscapes are true geological monuments, inasmuch as they manifest the impression which the artist receives from this state of things, and the assent of all men to the general truth of his picturesque representations.

43. The rocks, and all other grounds which, at the birth of our continents, were left with abrupt sections, were exposed in that state to the action of the rains and frosts; and those on which such causes could have a sensible influence, began to crumble down. I omit those rocks which are little affected by these causes, owing to their hardness and the continuity of their masses: such rocks commonly become covered with lichens and mosses, and suffer little from external causes. But the greater part of the abrupt faces of mountains were in great disorder, traversed by crevices in every direction, and chipped in their smallest masses; insomuch that atmospheric causes,

aided by gravity, exercised from the first a great influence upon them.

44. It is towards the top that the steep parts of grounds liable to demolition, lose most of their materials, because the rain-water makes its way from the upper surface into the fissures; so that these parts gradually retire, and thus what was at first vertical acquires a slope. Now, wherever the inclination of these slopes is no longer such, as that the fragments, detached by the action of the rains and of the atmosphere, can easily slide down to the bottom, their surface begins to afford nourishment to plants; and when they come to be quite covered, they are no more liable to degradation, unless the rocks below them, being the steepest, continue in a state of demolition, or unless they are attacked by torrents at their lower part; which, propelling in their course the materials which have fallen from the abrupt faces, prevent them from accumulating. In general, before the steep side of any eminence can be entirely covered with plants, it is requisite that, from the summits to the bottom, it be, by its degradation, which is always greater in the upper parts, and by the accumulation of the materials at the foot of all the parts originally abrupt, reduced to a regular slope, and that no torrent should any longer exercise its action at their base. As long as the fall of these detached pieces is frequent, vegetation cannot seize upon the slope formed by them; but as soon as this fall becomes less frequent, plants begin to grow on these new grounds, and at length cover them. Whenever, then, that part of a steep surface which rises above the slope formed of its fragments, is at length itself reduced to a shelving form,

vegetation is spread over the whole, and the process which every where puts a final stop to degradation, terminates at this point.

45. Here, then, is what assimilates the operations that take place in the interior of our continents, to those I have described in speaking of their coasts. All the asperities whatever of our lands, be their situations what they may, are thus liable only to be softened down by those causes, to which, for want of attention, the power of destroying the continents themselves, has been attributed: for these operations do not continue beyond the period when vegetation has covered both these softened eminences, and their debris around them. Vegetation takes place in no soil but what is in a state of rest; and when it is established in any place, it is both a sign of the soil being at rest, and one of the means of keeping it so: unless, perhaps, the force of some torrent should sap the slope of the fallen fragments: and this latter operation terminates, whenever the slopes are reduced to the point at which they are no longer subject to be attacked. This I have explained at large in my "Lettres sur l'Histoire de la Terre," &c. and M. Ramond de Charbonière has described it in a masterly manner, in his work entitled, "Observations faites aux Pyrennées;" having supplied the colouring to the draughts, merely delineated, but more extensive, which I had given. In these I had expressed the different states to which the actions of external causes have hitherto reduced the several parts of our continents subject to demolition, tracing them from their original state, which every where is easily ascertainable. In every part likewise, where these operations are not terminated, we may judge

how they will end; for without quitting the same mountains or hills, we find other places where a state of repose has succeeded, or is more or less likely soon to succeed, to the havock produced by the too rapid declivities of the grounds, or by the attacks of torrents. Now, this is a numerous class of various sorts of processes, to be met with every where, in which, by examining attentively what has been done, what is doing, and what remains to be done, before all traces of the first state of our continents shall be obliterated, we see clearly the slight antiquity of the era when our continents were abandoned by the sea.

46. The mechanical operations proceeding in the interior of our continents, likewise resemble those I have assigned to our coasts, in other circumstances as interesting in themselves, and no less characteristic of a general process which must have commenced not many ages since. The torrents formed by the rains in elevated spots, exercised against the steep grounds, and the accumulations of their debris, the same power that the waves of the sea exert against the steep parts of the coasts, and the accumulated materials which tend to form a strand at their feet. These torrents again, and the rivers, have attacked certain grounds which at first opposed their course, as the sea has attacked the promontories which obstructed the free course of its currents and waves; whence have resulted, within land, as well as on the coasts, steep cliffs, which did not exist before. Lastly, the rivers, by carrying down materials in consequence of these demolitions, form here and there in their course, new lands similar to those which, together with the waves of the sea, they produce along the coasts. This whole

process is as interesting in the history of mountains, of their inhabitants, and those of the banks of rivers, as that of the operations of the sea is in the history of our coasts, and of their inhabitants also: but as I have described it with the same care, and much at large in the work cited above, I shall likewise confine myself only to its principal features.

47. I have already proved, in my first Letter, that whatever havock the running waters appear to have made upon our mountains, all their pretended destructive power, from the birth of our continents, has done nothing more than retard the settling of the slopes of debris at the feet of the steep rocks; and that the greater part of the materials that they have thus set in motion, at times of great rains and melting of the snow, has served only to raise and level the bottom of the valleys which existed before the retreat of the sea. For we find scarcely any thing but sand at the entrance of those lakes into which the rivers discharge themselves as they flow from the mountains, and in which are deposited all the materials which these collected waters, after traversing the interior parts, have carried down so far; the whole amount of which is nothing in comparison with what the imagination of some geologists conceived. I have shown also, that the known progress of these sediments is among the proofs of the slight antiquity of our globe. I now, therefore, shall quit, though with regret, the abundance of interesting objects for a geologist, which all parts of a mountainous country afford, in order that I may proceed to the general effects of running waters on our continents.

48. Wherever the rivers have met with obstacles in

their course, they have had a tendency to demolish them. I pass over, (as I have done with respect to the mountains, and the sea coasts,) the solid rocks on which no external cause has any sensible effect, in order to come immediately to those places where we may visibly trace the whole of the past effects, their progress in known time, and their present advance; which supposes, that with regard to the rivers, they have been able to make a sensible impression upon the obstacles they have encountered. Now, here are two general operations, which began at the time that such obstacles occurred to bend their course. The grounds thus struck by the waters were excavated by their violent action; and cliffs were formed, which continued for a greater or less time, and in many places, still continue to crumble down into the current. The materials, thus detached and fallen into the stream, were carried down as far as its rapidity would allow, and then deposited wheresoever its force abated, which produced two sorts of new lands; the one formed in some lower part of the river's course, that was larger or deeper; which operation tended to give a regularity to its bed: the others opposite to the crumbling cliffs, when the river, in its effort to demolish them, sensibly gained space on their side, and receded from the other shore. These are joint operations still observable in many places, and which are found in many others, already terminated. I shall not particularly stop to consider the case, where the rivers have found natural channels without any great windings, and where thus they have had only to acquire a regular declivity: I shall confine myself in this respect to the remark, that in forming their bed in

these soils, rivers have in some places sunk deep into them, thus maintaining a more equal slope, and thereby forming steep banks at their two sides, where the effects of which I am about to speak have taken place as well as in the more complicated case of considerable windings of the streams.

49. The rivers have produced cliffs on one of their sides, only in the parts where the bent they received was at first too acute: they then tended to acquire an easier curve, by attacking their impediments. While thus they occasioned considerable demolitions, they rose by the resistance of the impediments, and the violence of their current in falling from hence into some lower part, made them carry down or deposit on the other shore, all the debris of the part attacked. But when, by these operations, their windings became less abrupt, and their declivity more uniform, the larger materials began to remain at the feet of the cliffs; and a dike gradually rose, which served to diminish the force of the current. By the accumulation of these materials, a strand comes at length to be formed at the foot of these steep banks, on which the river no longer rises, except at the period of inundations: the new falls of materials then extend, and raise this strand; and the cliff itself, which retreats further and further by its demolition, at length gets beyond the reach of the current: it then becomes reduced to an easy slope by the action of external causes, and vegetation fixes it. During these operations, the materials that the place attacked loses, are deposited either on the opposite side, or in some lower part in the course of the river, where the waters having more space to flow in, lose their rapidity.

There all the materials at first arrived; then successively the larger remained behind: insomuch that after the first operations of rivers, the new lands have been raised only by materials which have gradually decreased down to mere sand; and it at length happens that these grounds receive an addition of sand at their surface in times of floods only. The period thus comes when the river is confined in a regular channel, of which the new lands form a part of the boundaries; wherever it still continues to surmount them in high floods, it raises them by new deposits; at length it only rises and falls within settled banks, and the remaining part of the new lands becomes covered with verdure, or passes into cultivation.

50. Such have been, and still are, in many places, the real operations of running waters, which some geologists, on the supposition that they have been attacking our continents during an indefinite number of ages, considered as having produced all the sinuosities at their surface. As soon as the rains began to fall on our continents, their waters collected in the channels that the declivity and the sinuosities of their surface offered them; and when they once had taken those natural and inevitable roads, they could not change them; so that the rivers could not shift their course, except in some plains already horizontal, or at the bottom of large valleys, the bed of which they levelled by spreading over it the debris from the higher grounds. The first determined channels of the running waters, then, were the bottom of the chasms, and other sinuosities, of the mass of the strata, of which the anterior catastrophes are marked by very decisive characters; in such a manner, that we

may always determine, with respect to places where the rivers have produced real alterations, how they must have existed at the birth of our continents, and all the operations effected upon them since that time by running waters.

51. Among the places where it is easiest to study the history of rivers, are, as I have said, those at which their windings have been occasioned by grounds that have obliged them to alter their course, and were liable to demolition. There we discover the point where the attack has begun, and the excavation that has been made: we find besides, either lower down, or opposite to the excavated ground, the greatest part of its materials: for they have first levelled the bed of the river, and then formed new lands, always distinct from the original soil, both by their regular inclination towards the stream, and by the nature of their composition; they have no coherence, and the materials which compose them diminish in size, from the bottom to the surface. These opposite operations, are in many places terminated: then the lands formerly attacked, as well as the new lands formed of their ruins, undergo no more sensible alterations; but in other places these two operations, always coincident, of demolition in one part, and of deposition in another, continue in various degrees, and are more or less distant from their termination. Now, as near the mouths of rivers, where they empty themselves into the sea, and where they deposit all the mud they have brought down with them from their source, monuments and traditions are found, which mark several eras in the progress of the new lands they have thus produced; so we frequently find

in the upper parts of the courses of rivers, monuments which agree with these in the same chronometrical scale: I shall cite but one example, but that a very remarkable one, since the monuments are of the same nature, both at the mouth of a great river, and in a particular part of its upper course.

52. I speak here of the Rhine, with respect to which I have said above, that the Romans had built a custom-house near the mouth of one of its branches, the ruins of which, (as well as a monument relating to Agrippina) have been found in the marine deposit, which has from that time choked up this branch, and so completely, that sand-hills have been formed there, as on the rest of the coast of Holland. I now am about to point out another Roman monument of the same age; in a portion of new land belonging to a part of the course of that river, very far from the sea, attended with circumstances that will serve to confirm the whole process I have hitherto traced in the mountains, valleys, and plains.

53. The Rhine, before it joins the Moselle, flows a long way through a valley, whose sides were originally very steep and broken; but at present they are softened down in irregular strips, which, in a great part, are covered with vegetation. During the operations which have at length brought these broken cliffs to a state of almost entire repose, their debris have formed, along the present course of the river, a strand more or less wide, which encloses it, and on which the rubbish that still falls from some of the steep parts, accumulates. The place where the two rivers unite, is an open space where stands the town of Coblentz; and thither, while the sides of the upper valleys

crumble down rapidly, these rivers, then much agitated by the obstructions in their beds, have brought down very large fragments of stones: but by degrees they have become more tranquil; the materials they carried down have been successively smaller; at last they have conveyed nothing but sand, and at this day, flowing between the banks they have themselves formed, these rivers overflow them but very rarely. It is from one of these portions of new land, that I shall now deduce the history of the Rhine.

54. I passed through Coblentz, in 1778, at the time they were laying the foundations of the new electoral palace: the late M. LA ROCHE, chancellor to the elector, presided over these works, and he invited me to accompany him there, that he might show me some very interesting objects. A very large and deep excavation had been made in the new land formed at the mouth of the Rhine; and M. la Roche showed me on one of the sides of this hollow, the section of a kind of well, many of which had been found in the space thus excavated, and in which had been found urns containing ashes and bones, various kinds of sepulchral attributes, after the manner of the Romans, and some legionary stones: a circumstance which agrees with the remains of Roman camps, found in many parts of the valley. Here, then, is a fixed epoch in the history of this new land, the composition of which I shall now proceed to describe.

55. The bottom of this excavation, was composed of large stones worn by attrition; to these succeeded (as observed in the lateral sections) gravel, diminishing in size from the bottom upwards: it was in this

gravel, to which sand had begun to succeed, that the Romans had dug the wells I have been mentioning: since that time the top of these wells has been covered by eight feet of pure sand; and at this day, the Rhine, having settled its bed, but seldom rises to this height. The time when the Romans carried on war with the Germans, and pushed their conquests as far as the Batavians, is known; and thus we have two of their monuments of the same period; the one buried by the sediments of the Rhine, in a part of its inland course, the other in the new land, at one of its mouths. Now, the place which these Roman monuments occupy in this mass of transported matter (an accumulation which could have begun only at the birth of our continents) transforms these historical documents into geological monuments; it is an example of the chronometrical scales to be found in the course of all rivers, agreeing with each other, and with every other kind, and prevent our referring the origin of our continents to an epoch more remote than that of the deluge in sacred chronology.

56. The whole that I have brought together in this Letter, to prove, in different ways, this great geological fact, is only a sketch of what I have already published on this subject in my "Lettres sur l'Histoire de la Terre," &c.; and the attention of naturalists being at present fixed on this physical chronology, it will, in the end, obliterate all the fabulous traditions of an unfathomable antiquity, and all the systems founded on them. I have already cited M. de Saussure and M. de Dolomieu, for some recent facts, and I cannot better conclude on this subject, than by the following passage from the latter of those great observers.

(Journ. de Physique, Jan. 1792.) "I will defend," he says, "a truth which appears to me incontestable, and of which I find proofs in every page of history, as well as in those in which are recorded natural phenomena; that the present state of our continents is not ancient, that it is no long time since they have been given up to the dominion of man."

After having proved that we cannot refer the birth of our continents, to a period more distant than that at which the Mosaic history fixes the deluge, I have now to show, that the revolution, by which, according to every fact in geology, our continents had their origin, must have been this very event, such as it is described in the Mosaic narrative. This I shall do in my next Letter.

I have the honour to be, &c.

LETTER VI.

A Physical Commentary on the eleven first Chapters of Genesis.

Windsor, September, 1794.

SIR,

1. IN my last Letter I collected together the principal features of a numerous class of phenomena, tending to demonstrate that *the birth of our continents must have been preceded by a sudden revolution, during which the ancient continents sinking down, formed a new bed for the sea;* and, that *the epoch of this revolution is not more remote than that of the deluge, according to the Mosaic computation.* What then becomes of that immense antiquity, to which certain Asiatic nations lay claim, and of which some geologists have availed themselves, to ground systems as fabulous as these chronologies?

2. While geology has made advances in illustrating the history of our globe, it has been strongly supported by the enquiries of learned men into the mythological fables, which had contributed to its obscurity. In the year 1776, Mr. BRYANT published a valuable work, (the Analysis of Ancient Mythology), in which, tracing by a most laborious and learned analysis, the mythologies

of Greece and Rome, up to their Egyptian and Asiatic sources, he proves that they all allude to the *history of the deluge*, as related by Moses; marking by the distinct characteristic circumstances of this event, the epoch of a *renovation of the human race, by a personage conspicuously described, who was miraculously preserved with his family, in a vessel*[1]. These results, as far as they relate to the nations of Asia, have been since confirmed in the three volumes hitherto published of the Asiatic Researches, the fruits of the learned enquiries of a most important literary society established at Calcutta, under the presidency and direction of the late Sir WILLIAM JONES. Lastly, in Mr. MAURICE'S

[1] For striking coincidences of Chaldæan, Grecian, Phrygian, and Hindu traditions, with the Mosaic account of the deluge, see the first volume of Burder's Oriental Customs. See also Philip Howard's Scriptural History of the Earth and of Mankind, Letter I. with the Notes and Illustrations.

The following observations on a work entitled "Diluvium cum tribus aliis Mahâbhârati præstantissimis Episodiis," are extracted from the Foreign Review, No. VII. p. 216. "A particular interest is attached to the episode on the Mythos of the deluge, the agreement of which, with the reports given in the first book of Moses, is, in some instances, really striking. The substance of the Hindu account is this:—The Lord of the universe once appeared to the pious King Manu, acquainted him with the general imminent inundation, and ordered him to build a vessel, to enter it at the time of danger, and to take with him the seeds of all the various plants. Manu obeyed. The vessel, led and protected by the Deity, floated many years on the summit of the Himavan mountain, where it was tied at the commands of the Deity; and that point is, until this day, called Naubandhanam, or the tying of the ship······The grand and truly majestic simplicity with which the episode on the deluge is written, imparts to it such an air of high antiquity, that we do not hesitate to place it amongst the oldest relics of Sanscrit composition."—ED.

publication on *The History of Hindostan,* we have a recapitulation of all that has, through a length of time, been discovered on this important subject, connected with the modern discoveries, and accompanied with many very interesting remarks.

3. Hitherto, however, we have only ascertained with more precision, a resemblance, which unbelievers had already noticed between the Pagan mythologies and the book of Genesis, whence they had concluded, that the latter was also a mythology compiled by the Hebrews from notions which they had adopted, during their captivity in Egypt, and from the opinions of the several nations by which they were surrounded. However this resemblance might formerly have tended to such a conclusion, notwithstanding the absurdities of the Pagan mythologies, compared with the simplicity of the Mosaic narrative, notwithstanding, especially, the monstrosity of their polytheism, so contrary to the sublime doctrine of one only God, the Creator and Preserver of the universe, professed by the Hebrews at their departure from Egypt; still the history of the earth must necessarily, at this day, destroy for ever the illusion. Those Pagan mythologies were all connected, although in different ways, with the notion of an unfathomable antiquity of their respective nations; each of them reckoning dynasties, in which ages were accumulated by thousands. Moses, however, addressing himself to his own people, who had recently quitted a country where those notions prevailed, and tracing down the history of the new race of mankind, from the same physical epoch, common to all the mythologies of the Pagans, connects that history with that of a small number of

generations successively characterised by distinguished personages, sprung from one another. How widely different is the supposed imitation from the models assigned to it? How shall we impute to the leader of the Hebrews, who in other respects manifests such wisdom, the folly of contradicting so grossly the opinions which they must have learned from the Egyptians, if it was from that source that he had himself drawn his fabulous accounts? The contrast is too great to admit of a doubt that Moses, narrating with such simplicity to the Israelites all that was of importance for them to retain respecting their origin, traced out a chronology with which they were themselves acquainted:—but we have at the present day a yet more decisive consequence to deduce from that contrast. It is most certain that of the compared histories, the one which describing the events of the new race of mankind, from the same physical epoch of the globe, places that epoch at its true distance, is that which contains the truth on all the other points. That distance of time must necessarily coincide with the antiquity of the new continents on which that new race established itself; accordingly, the question is resolved into that of the antiquity of those continents. Now, I have shown in my preceding Letter, by the concurrence of numerous phenomena of the same kind, that it is not possible to assign to them a greater antiquity than the Mosaic chronology assigns to them. Here, then, we have the greatest character of veracity impressed upon the book of Genesis; and it is the more important, that it alone overthrows both the fabulous chronologies intermingled with such great truths in the heathen mythologies, and the geological

systems by which infidels have attempted to support those chronologies against the MOSAIC REVELATION.

4. The deluge, which, in all the ancient traditions, is the physical epoch marking the commencement of a new race of men, is described by Moses with circumstances so precise, that if they are true, they must be impressed upon the whole of our globe as forcibly as its *chronology:* and now, in proving that they are so, I shall not confine the character of Moses to that of a faithful historian, but shall make it manifest, that he must necessarily have been directed in his narrative by God himself.

5. No account of events so important as those of which Genesis treats, could be more simple than this of Moses: the history of mankind is the chief object which he is desirous to impress on the memory of the people entrusted to his direction. He first, therefore, expounds to them, in a succinct manner, the principal operations by which, at the word of God, the earth was prepared for the reception of man: then, continuing their history, and arriving at the era when the human race was renewed after a deluge, in which God granted his protection to Noah and his family, he relates some circumstances of that event: after which he confines himself to the history of that family which repeopled the globe. In this narration, Moses does not stop to explain or prove the events he treats of, but simply relates them; the Israelites knew, *from tradition,* the truth of many of these circumstances; and they admitted, without hesitation, those with which they were unacquainted, because Moses exercised a *supernatural power,* which manifested him to be the minister of God. We have not now the benefit of

such direct proofs, but the phenomena of our globe remain, and they bear the same testimony to the narrative of Moses.

6. I shall begin with the Almighty's revelation of himself to Noah on the approach of the deluge (Genesis, chap. vi. 13.) "And God said unto Noah, the end of all flesh is come before me; for the earth is filled with violence through them: and behold, I will destroy them *with the earth.*" The more literal translation of the latter part of the verse is, "I will *destroy them,* and the *earth* with them." We see that the term *earth* does not here signify the terrestrial globe, but the *land* inhabited by man. It was, therefore, the destruction of those continental parts that was foretold to Noah. Now geology, as I have explained in my former Letter, proves, that at a period corresponding with that assigned to the deluge, *ancient continents sunk;* and as the sea rushed over them to occupy their place, *all the organized beings necessarily perished.* Thus geology, a science but very lately sufficiently advanced to explain to us the real history of the globe, comes in, as an evidence that, at this very period, *the human race was destroyed.*

7. Let us, however, suppose for a moment, that the history of the deluge, thus shown to be real, is only the record of a tradition, true as to the events, but in which has been inserted, by fraud or superstition, a pretended *revelation* from God to the family which was preserved. Then we must necessarily admit, that the deluge surprised this family as it did the rest of mankind; that by some fortunate circumstance they found themselves inclosed in a vessel with abundance of provisions; and that this vessel, instead

of being swallowed up in the chasms that were opened in the old continents (though this would certainly have happened in the natural course of things) floated against the currents of the sea, and at length rested against one of the *islands* of its former bed, before its waters had entirely abandoned it: in such a case, what could have been the facts observed by this family? That after an extraordinary rain, during forty days and forty nights, their bark had been set adrift; that in this state it had been violently driven about on a body of water extraordinarily agitated; that during a certain period they saw nothing but water under the horizon; that at the end of that time, a raven and a dove gave them notice of their approach to land; that at length their vessel rested on a *mountain,* where they disembarked; from which moment the waters gradually retired from the land on which they found themselves.

8. This, I say, must have been all that any spectators, accidentally preserved in such a catastrophe, could have observed or described; it never could have entered into their thoughts, that this dreadful catastrophe had been caused by the sinking of an immense extent of land, and a total displacement of the sea: it is geology that unfolds to us that great revolution, written on our globe, in indisputable characters; and it thus necessarily recalls to our mind the important circumstance we had by our supposition set aside for a moment, namely, the prediction of the deluge to Noah, purporting, that all the inhabited parts of the globe should be destroyed. Here then is a revelation confirmed by unquestionable facts; and this first investigation might serve to overthrow

all the arguments of unbelievers against revelation in general; but we shall see that the whole Book of Genesis bears the same character.

9. Not only the family of Noah was struck by this event in such a way as geology necessarily shows they must have been; but they knew, and transmitted to their posterity, that God had interposed on this occasion, and that it was by his power they had been preserved: we know this from the ancient mythologies, the first foundations of which certainly refer to traditions of Noah's family; for the chronology of this family being confirmed by the phenomena of the earth itself, we cannot doubt that all the traditions must have proceeded from the same source as that of the Israelites. Now the nations of the East have applied the whole strength of their imagination to describe a fearful agitation of the sea during a *deluge*, and many other prodigies; or rather, it is to their lofty ideas of that event, preserved among themselves, on which they exerted all the power of their fancy when left to their own guidance, that this strong character of Oriental imagery is attributable: and they had not lost sight of the circumstance of a *superior power* having presided over this event; for they in particular ascribe to such a power, the preservation of a *bark* (notwithstanding the violent agitation of the ocean) containing a *holy person*, with his family, consisting of *seven people:* we may see this particularly explained in Mr. Maurice's *History of Hindostan*, pp. 351, &c.

10. Moses had not in view such models; else he could not have avoided using their imagery: neither

did he write from a knowledge acquired in geology or physics; for these sciences were not yet born; observations on nature had till then been chiefly directed to the common wants of human life, and even the origin of the degree of science which they possessed was as much wrapped up in the veil of mythology, as that of the new race of man. The narration of Moses was extremely simple, and all it contains is at the present day confirmed by nature: I have just made this evident with regard to the first circumstance in the relation, namely, the *prediction of the destruction of the ancient continents;* and, after I have reminded you of some geological facts, I shall point out from the narrative the manner in which that destruction took place.

11. I have explained in the course of my former Letters, the causes as well as the effects of certain great changes that took place in our *atmosphere* during the formation of our globe, such as we see it at present. The causes, which are connected with the production of our *mineral strata,* are the succession of *expansible fluids* that issued from the caverns within the globe, at each revolution that happened at the bottom of the sea; the effects, as far as regards the atmosphere, are to be traced in the successive changes that befell the race of marine as well as of terrestrial animals, and the several tribes of vegetables. The last revolution of our globe, that which produced the deluge, was of the same nature as the former, and of considerable extent: thus the atmosphere must have, at that time, undergone a great change; of which we have already had a direct proof in the extinction,

without the tropics, of animals which formerly existed there; and in the total extinction of some of their species.

12. Without entering here into any discussion respecting *rain,* (although no doubt a very important subject, which I have discussed in several of my works,) it will be sufficient to remark, that naturalists are far from being agreed on the cause of that phenomenon, and that, in general, the causes of all the meteors still remain involved in great obscurity. A very slender degree of attention and reflection, for example, is requisite to excite our astonishment, when we observe, in the midst of a fine day, *clouds* forming suddenly in the atmosphere, increasing in size and density, and pouring down *torrents of rain,* often accompanied with thunder and hail; then clearing away, and re-appearing, perhaps frequently attended by the same effects. Whence proceed these remarkable phenomena? Doubtless, from great and sudden modifications, operated in some stratum of the atmosphere, by the introduction of new fluids, but of a nature hitherto totally unknown.

13. I now return to the deluge. The rain of forty days and forty nights, described by Moses, as an extraordinary phenomenon, was one of the effects of the change that was operated in the atmosphere by the ascension of the expansible fluids, that escaped from the innermost caverns; when, at the commencement of the revolution, the liquid penetrated into them, and this was the prelude to those meteorological operations which brought the atmosphere into its present state. But from this extraordinary fall of water resulted only a first inundation of the *habitable*

parts of the globe, and Moses does not confine himself to the indication of this cause only; for he makes mention of the *fountains of the abyss,* which, according to the language of Scripture means the sea. Now, we are about to trace the operations of these causes in the remarkably simple narrative which he gives of this great event.

14. After these words, [Genesis, chap. vii. 17.] "And the *flood* was *forty days* upon the *earth;* and the *waters* increased, and bare up the ark, and it was lift up above the *earth;*" (which part relates only to the continuance of the rain, and which would have been the end of the inundation if the *rain alone* had produced it:) it is said [verses 18, 19,] "And the *waters prevailed,* and were increased greatly upon the earth. And the ark went upon the face of the waters. And the *waters prevailed exceedingly* upon the earth; and *all the high hills,* that were under the whole heaven, were *covered.*" This expression, "under the whole heaven," signifies only the whole horizon of the inhabited lands; for the sphericity of the earth was then, and for a long time afterwards, unknown to its inhabitants.

15. It was then by the extraordinary *rain* which succeeded the disruption of the caverns under the lands that were on the point of being destroyed, that the ark was set afloat: after which these lands sunk by degrees, and the *sea* flowed in from all parts; by which cause, though the *rain* had ceased, "the waters *prevailed* and were *increased* greatly upon the earth." It was thus that all the mountains of those parts of the earth were submerged, and even overthrown into the caverns; and the ark would have been carried

along by some of the currents and swallowed up in those chasms, had it not been for the *Divine interposition*, which is the principal point with Moses, in his narration, and the emblems of which are found in all the monuments of ancient mythology. The ark then floated *miraculously* against the currents of the sea, and being borne up on its ancient bed, while it still covered it, rested upon one of those islands which soon after became one of the *mountains* of the new continents. Thus, it is already evident in this part of Moses' concise narrative, that the sea overflowed the ancient lands: and now, by consulting natural history, we shall find also in the rest of that narrative, that the retreat of the waters there mentioned, was that of the sea, which abandoned its ancient bed.

16. I need not prove that *our continents have been the bed of the sea;* there is now but one opinion on this subject among naturalists. When the sea changed its bed in this revolution, all the hollow parts which happened to be in the new lands, remained at first full of its waters: but soon the waters that fell in *rain* were added to these; and in every part where the extent of land from whence these waters descended into hollow places, was very great in comparison with the extent of those basins, the superabundant water flowed into their lower parts; so that by degrees the rain water took the place of the salt: and it is in this manner that the greater part of our lakes have been formed. But on these new continents, there were also vast basins, where the rain waters which came into them were not sufficient to compensate for the evaporation that took place at their surface; by which means the quantity of water

was diminished, instead of being augmented; and this decrease continued till the extent of the accumulated waters became so reduced, that there was an equilibrium between the water produced by the rains, and that which was carried off by evaporation; so that the water remained salt. Such is indisputably the origin of our *salt lakes,* such as the *Caspian Sea;* for all the systems that have been imagined to explain their saltness, as well as that of the sea, by supposing a continual lixiviation of the lands, and the calculations made accordingly, by which the antiquity of our continents appeared to be millions of years, have had the same fate as those in which it was attempted to explain their formation by slow causes: they have vanished before the direct proofs of the small antiquity of the present state of our globe.

17. Amongst the circumstances of the deluge, those which regard Noah himself, his family, and the ark, are the more important, as from these unbelievers have hitherto drawn those objections, which appear most specious in the view of the generality of men; while, on the contrary, it is these very circumstances which will serve the most readily to dispel those prejudices.

18. If Moses, as deists pretend, had invented only a mythology, upon the model of those that existed in his time, and from some inconceivable motive, had affected to contradict them with regard to the antiquity of the new race of men, he would not have committed so gross a mistake, as to suppose olive-trees growing upon a *mountain,* and cause a leaf to be brought from one of them to Noah by the dove: for

the Israelites must have known that this tree is never found on mountains; and by placing the deluge at so short a time back, he had no means of covering his mistake, had it been one, with the veil of time. Tournefort, in the description he has given of Ararat, has not failed, as a botanist, to mention, that no olive-trees grow there; and this remark alone has made many unbelievers; it would not then have escaped the Israelites, or Moses himself, had he been writing a fable: but he spoke of the epoch of the landing of Noah on this mountain; that is to say, of a time when less than a year had elapsed since it was an *island* in the former sea. This circumstance, Sir, strongly excited your attention during our conferences; it is, in fact, of great importance in many points, which, as they are developed, will further evince the truth and sublimity of the recital of Moses.

19. We find in chap. ix. 3. of Genesis, that God said to Noah and his family, after their descent from the ark, "Every moving thing that liveth shall be meat for you, even as the *green herb* have I given you all things." Does not this last expression represent the family of Noah as surrounded with *verdure* on Ararat? If, however, Moses had been writing a fable, would he have represented the summit of a mountain as verdant, when he had just stated that the water had covered the highest mountains? It required but very little attention to judge, that in such a state of things, the family of Noah, on their quitting the ark, would have found only *mud* every where upon the surface. But the Israelites knew, from their own traditions, that these parents of the new race of mankind found both herbs and trees on Ararat.

20. We further find at verse 20 of the same chapter, "And Noah began to be a *husbandman*, and he *planted a vineyard.*" Moses neither in this place, nor in any other part of his narrative, aims at giving the history of the vegetation or cultivation of these new lands; and in fact it would have been unnecessary in addressing himself to the Israelites of his times, since they knew it from tradition: the vine, therefore, is mentioned in this place, only because of the verse following, where, continuing to speak of Noah, he adds, "and he drank of the *wine*, and was drunken:" a circumstance which gave occasion to the setting forth the characters of his sons, and had consequently considerable influence on the events that followed with respect to this race of mankind: but we are no less here informed of two important facts; one, that Noah found the *vine* on the same mountain, whence the dove had brought the *olive leaf;* a mountain also represented as covered with verdure; the other, that he, immediately after his landing, applied himself to *husbandry*, one of the first acts of which was to transplant the vine.

21. From the preceding Letter, it will be readily perceived, how geology serves to explain these great features in the MOSAIC HISTORY; but before we proceed to that point, I shall show why, in giving his account of these circumstances, as connected with the history of Noah and his family, he had no occasion to be more explicit than he has been; since the people to whom he addressed himself were well informed of them.

22. We have already seen, in general, that the ancient mythologies were entirely founded on certain

traditions of the deluge; thus we may be able to judge from these, what the Israelites must have known from their own particular traditions. Now, we first find in their *emblems*, and even among the objects of their *worship, the dove flying towards the ark with a branch of olive.* Moreover the great personage of whom these mythologies make mention as miraculously preserved from a flood, offered up on a mountain *the first sacrifice to the Supreme Being;* a circumstance which is very striking, since it is mentioned by Moses in his account of Noah. This personage is likewise spoken of in them, under different names and emblems, as *the first cultivator of the earth;* he who *first tamed the bull,* and subjected it to the yoke for ploughing; he who *first planted the vine;* and generally the first instructor of his race in *all the arts.* Here then we have all these circumstances mentioned cursorily by Moses; the olive branch, the vine, the renewal of agriculture, and a first sacrifice on a mountain, preserved in the *traditions of the Pagans;* and as these traditions were the only source of their knowledge, we find in them traces of events confirmed at this day by natural history, which Moses, while furnishing instructions more necessary to the Israelites, was under no necessity of recalling to their memory, and which accordingly he does not mention.

23. Moses, for instance, does not speak of the influence of *mountains* in re-peopling the earth, although geology teaches us so evidently that it is from them the greater part at least of the several species of plants and animals proceeded; a circumstance however implied in his recital, as we shall see in the sequel. But if this fact be true, we shall be enabled to understand

how greatly Noah and his family must have been struck at observing the animals descending from the mountains in proportion as their food was propagated on the lower grounds. Now their several accounts, on this subject, must have been attended with very marvellous circumstances, to have so far excited the imagination of their successors, with the exception of the family of Shem, as to lead them to the conception and admission of certain beings, who had obtained from the Deity permission to *churn* the waters of the deluge by the whirling of a mountain, till the *water of life* was recovered, and flowed down its sides to reanimate expiring nature. Here doubtless is a gigantic stretch of imagination; but geology points out the foundation of it at this day, in a fact which must have caught the attention of the family of Noah; and the following is another circumstance of a different kind, which at first view appears as extravagant as the former, but which, however, I consider as having been transmitted to them by the same tradition, precisely as they relate it; and even as that which by powerfully exciting their imagination, has had the greatest influence in the production of their mythologies. In describing that violent agitation of the *ocean*, true in itself, though they assign it to a fabulous cause, they mention that there issued forth *clouds of smoke* and *torrents of fire*. Now I have reason to believe, from the monuments of *volcanic eruptions* of which I have treated in my fourth Letter, that of the volcanic hills of our continents, those which are not encircled by strata produced in the sea, as well as many of the volcanic islands, were formed during the revolution of the deluge; and that thus the family of

Noah may have witnessed that great phenomenon, though Moses makes no mention of it, any more than of the violent agitation of the water. The Israelites knew these facts as well as the descendants of HAM and JAPHETH; and Moses omits every circumstance that is foreign from his principal object.

24. We may now judge of the importance of the labours of Mr. Bryant and of the Asiatic Society; which, by disclosing the real spirit of the ancient mythologies, have dissipated the obscurity that through the neglect of early tradition amongst the Jews, hung over the Book of Genesis; and how much we are indebted to Mr. Maurice, for having brought together a collection of original documents in his History of Hindostân, where we find, particularly at pages 341, 354, all the circumstances I have mentioned, together with the following, which, considering this loss of traditions among the Jews, is of very great importance to us. The same personage who in these mythologies is pointed out to us by so many characteristic traits to be Noah, is still further commemorated in them, as having brought forth with him from his *bark* a quantity of *seeds* which he had there *preserved*, in order to renew their races after the deluge. Now, natural history also supports this tradition; for we see by experience, that the preservation of the plants, most useful in our fields and gardens, depends on *culture;* they gradually perish if left to themselves, and are not to be found among the *spontaneous plants.* This tradition then, serves effectually to resolve those difficulties, which erroneous interpretations of the Book of Genesis had successively produced; for we not only have here a further indication of the means by

which vegetation was renewed after the deluge, but we learn at the same time, that, even on the *old continents,* culture was necessary for the preservation of the same plants; a conclusion that agrees with the sentence pronounced upon Adam on his being driven out of Eden, which is a material point in Moses' narrative, and to which I shall return.

25. As long as it was supposed that on quitting the ark, Noah and his family inhabited the same lands which had existed before the deluge, every thing was involved in difficulty; for, without speaking of the deluge itself, which, under such a mistake became incomprehensible, it was impossible to conceive that the smallest blade of grass could have been preserved under the waters of the ocean, and particularly upon a bottom, which, from the top of the mountains to an unknown depth in the plains, is nothing but a mass of strata in the greatest confusion, full of the remains of terrestrial vegetables, and marine animals. Such a gross contradiction between the supposed sense of Genesis and the *facts,* was very fit to produce unbelievers; but it was the error of the interpreters of Scripture, who, after the true traditions had been effaced from the minds of the Jews, substituted their own conjectures for the plain sense of the expressions used in Genesis. At the very beginning of his description of the deluge, Moses relates that revelation of God to Noah, which announced, that *the lands then inhabited* should be destroyed. It was not, therefore, upon those *lands* that the ark rested, but on *new continents.* When, accordingly, Moses comes to his short account of Noah and his family quitting the ark on Ararat, he could with propriety mention the olive-tree,

the green herb, and the vine; but these circumstances referred to other objects; and he had nothing to fear from the criticism of the Israelites, since these particulars must have been known to them, as they were to the Pagan nations, namely, through traditions proceeding from the same family.

26. Now to what period of time are we to assign these different circumstances common to the account of Moses, and to the ancient mythologies? Must we refer them to an epoch so immensely remote as these mythological systems suppose? I have already answered this question generally, by proving the small antiquity of our continents themselves, which have thus been peopled; but I shall now proceed to point out a striking connection between one of the proofs of this great truth, and the above parts of the Mosaic narrative, which unbelievers have pretended to be manifestly fabulous.

27. I have proved from geology, that before the deluge, the summits of our present mountains were *islands* in the primitive sea; and I at the same time observed, that being then in the lower part of the atmosphere, they enjoyed a temperature fitted for all sorts of vegetation. Now in the revolution which the deluge produced, the sea, in changing its bed, sunk considerably lower; the atmosphere therefore subsided with it, and the former islands, become now the summits of our mountains, were situated in a cooler part of the atmosphere. If then Noah and his family found the olive-tree and the vine on Ararat, as well as other plants, which no doubt subsist there no longer, it is because they had not had time to suffer from the change of their *situation* with regard to the atmos-

phere: but as by agriculture these plants (together with those the seeds of which Noah preserved with him in the ark) came to be propagated in lower grounds, the temperature of which suited them, they gradually decayed in that region, now too cold for them, and were replaced by a greater multiplication of those plants which were more capable of subsisting in their new situation. Now it was at the same period, and owing to the same cause, that a phenomenon of another kind commenced, of which I have treated in my preceding Letter, and which supplies a direct proof of the change that has taken place on our globe; namely, the *growing accumulations of snow and ice on our higher ranges of mountains.* This phenomenon, I say, leaves us no room to doubt, that the summits of our mountains have changed their region in the atmosphere; and when I referred to it in my preceding Letter, I then observed, that by comparing the whole mass of ice thus produced up to our own times, with the course of its progress in known times, it is impossible to assign to them an antiquity more remote than the period of the flood in the account of Moses; in which respect this phenomenon accords with all the other natural chronometers.

28. Thus, in the resemblances we trace so clearly, between the ancient mythologies and the history of Moses, resemblances too marked and too numerous not to show a connection between the sources of these different traditions, geology now unveils the TRUTH. It is Moses, and Moses only, that has transmitted to posterity the true account of these times, because he deduced it from an infallible source, even the source whence *nature herself* proceeds, which at this day con-

firms the truth of his narrative; and the resemblances we discover between it and these mythologies, but which were hidden beneath their fantastical images, arise from the *traditions* of the sons of Noah, whose authentic recitals of what they had observed during and after the deluge, gave birth to the most extravagant flights of imagination in the descendants of Ham and Japhet, when they were separated from the posterity of Shem, and thus deprived of the instructions of Moses.

29. Thus again, are all those *psychological* fables set aside, in which, by a vain analysis of the human understanding, at a period when it was already *instructed,* some philosophers have pretended to derive from the powers of reason alone, all the religious notions scattered among mankind: for we now see, that the origin of idolatry is to be referred to the debasement of a pure *Theism,* the foundation of which was laid in the immediate revelations from God to the first race of men, and of which the history was transmitted to the new race through GENESIS, written with that view by the Divine command. The worship of God instituted by Noah at his descent from the ark, was successively corrupted into the worship of Noah himself, under different names; into that of his sons and their first descendants, and even into the worship of the mere *emblems* by which the several circumstances of the deluge were represented; and when once men had begun to disfigure by the wildness of their imagination, objects, the true meaning of which they would have been unable to discover, without a reference to their real origin, no bounds could be put to the excess of deviations in the few,—actuated

by secret views,—and of credulity in the many: as Mr. Bryant has, among other learned men, made it appear, in the history of the propagation of the *Asiatic* and *Egyptian* mythologies among the Greeks and Romans. Nevertheless, through all these deviations, the primitive notion of a SUPREME BEING, to whom these gods of their own invention were subordinate, prevailed at all times among the Pagans: a strong instance of which, as far as relates to the *Indians*, we have in Mr. Maurice's history of Hindostan, p. 359. What becomes then of all the speculations on a pretended derivation of theism from the *human understanding*, since it is thus ascertained, that a true *theism*, proceeding from *revelation*, did exist among the first progenitors of the present race of mankind?

30. Besides these circumstances so clearly proved, which directly give the sanction of truth to the recital of Moses, there is another which will serve to demonstrate more and more clearly that the sacred historian, in impressing on the Israelites, as a rule for their conduct, the sublime ideas of the benefits, particular commands, and judgments, derived from God, did not dwell upon circumstances which they already knew by tradition from their ancestors. If his history had been a fable, Moses might well have been expected to show as much imagination, as those painters who, from false ideas of the deluge, have drawn pictures in which men are represented as crowding to the tops of eminences, and flying from rock to rock to escape the waters. Moses then, representing to himself Mount Ararat, where he informs us Noah landed, as covered with the *dead bodies* of the inhabitants of the country

who had there sought refuge, would have substituted poetry for painting, and we should have had an elegy in the place of those fantastic pictures. But he is silent upon the subject, because he was writing the true history of Noah and his family, who, landing on an island of the ancient sea during its retreat, found there no human remains.

31. This, however, under a more general form, was the ground of one of the arguments of unbelievers; who, setting out from the false ideas which prevailed on the nature of the deluge, objected to the history of Moses, that, if it had really taken place, we ought to find in our strata *human reliquiæ*, as well as the remains of *terrestrial animals;* which, however, is not the case. But Moses says expressly, that the *lands* occupied by mankind were *destroyed;* and geology confirms this fundamental circumstance. Thus, far from this absence of *human remains*, as well on Ararat in the description of Moses, as, in general, among the organized bodies buried in our strata, being an objection to the truth of the sacred history, it is on the contrary, a very remarkable confirmation of it[1]. With

[1] "Not," says De Luc elsewhere, "but that human reliquiæ may accidentally be found among our fossils.... Since, while our present lands formed the bed of the ancient sea, there existed inhabited continents." He then proceeds to observe, that in the narrative of Moses we meet with two circumstances which would sufficiently serve to account for the absence of human remains. The first is, that men began to inhabit the globe at a much later period than animals, namely, about seventeen hundred years only before the deluge; whilst our continents enclose the remains of animals far more ancient. The second is, that mankind, from the first, practised the rites of sepulture, a circumstance which sheltered their remains from the

respect to the *carcasses of terrestrial animals* discovered in these strata, they were, as it has before been explained in the fourth Letter, buried there by the waters of the sea, before the deluge.

32. Of all the mistakes produced by abandoning the literal sense of GENESIS with regard to the nature of the Flood, that which has produced the greatest number of unbelievers, is the interpretation which has consequently been put upon the command from God to Noah, with respect to the preservation of *animals*. If the waters, as was imagined, had in effect covered the highest mountains *all over the globe*, it must necessarily have followed, that every animal now existing, had proceeded from their respective couples preserved in the ark; and so it has been conceived. I shall not stop to notice the difficulties and improbabilities that arose from such an interpretation; they are well known from the commentaries of unbelievers; but let us pursue the history of Moses, to see if their arguments against his commentators, prove any thing against himself.

33. The passages they interpret in this manner, begin at verse nineteen of the sixth chapter of Genesis, where God speaks thus to Noah:—"And of *every living thing* of all flesh, two of every sort shalt thou bring into the ark, *to keep them alive with thee;* they shall be male and female." This, doubtless, is a *general* expression, which we also find in the subsequent passages relating to the same subject; but, as

accidents that befel the carcasses of animals, which were frequently drifted by floods and rivers to the sea.—Lettres sur l'Histoire de la Terre, &c. vol. v. p. 660. 1779.—ED.

early as the twenty-first verse, we meet with a general expression of another kind, which will assist us in the interpretation of the former :—" And take thou unto thee *of all food that is eaten,* and thou shalt gather it to thee; and it shall be for food for thee and for them." Let us proceed to the descent from the ark. God first tells Noah and his family (chap. ix. v. 3.): "*Every moving thing that liveth* shall be *meat* for you; even as the *green herb* have I given you *all things.*" Now, do we not find in these *general expressions,* compared with each other, a form of speech very common, not only among the oriental writers, but in every language, when a certain totality is to be expressed, which the circumstances serve to explain without ambiguity? Noah was not mistaken with respect to the orders he received; they were so expressed as to enable him to comprehend what animals he ought to take into the ark, *to keep alive with him,* and also what provisions were necessary for their food during the deluge. It is not in the short account of Moses that we can expect to find these details; it is evident through the whole of his narration, that he passed rapidly over such circumstances as were previously known to the Israelites by *tradition;* otherwise he ought at the beginning of the account of the deluge, as predicted to Noah, to have indicated its duration also, which surely was revealed to him, since it was necessary he should be " informed of it, in order to proportion the quantity of provisions to be taken into the ark." We hence perceive, that Moses did not think it necessary to enter into such details with the Israelites, because they knew them from their traditions.

34. Lastly, all doubts on this head vanish when we come to the following passage, containing one of the declarations of the Almighty to Noah, after his quitting the ark (chap. ix. v. 8, 9, 10.): "And God spake unto Noah, and to his sons with him, saying, and I, behold I, establish my covenant with you, and with your seed after you; and with every living creature that is with you, of the fowl, of the cattle, and of every beast of the earth with you; from all *that go out of the ark*, to every beast of the earth." Does not this repetition of the words "with you," joined to the expression of "all that go out of the ark," corresponding with the order given to Noah, "two of every sort shalt thou bring into the ark, to keep them alive with thee," establish an evident distinction, between the species of *animals* that Noah had taken into the ark, and which *had come out of it with him*, and "*all the beasts of the earth?*" Here, geology teaches us, why the Israelites, unlike those commentators who had mistaken the nature of the deluge, sought not a sense in these expressions different from that which naturally belongs to them: they knew that after the retreat of the waters of the flood, a number of *animals* descended from the *mountains*, and dispersed themselves over the surrounding countries, in proportion as their means of sustenance increased; as we have it figured in the ancient mythologies, by the *water of life*, which began to flow from the sides of a *mountain*.

35. Thus, setting aside the animals immediately needful to man, and those that, for particular reasons, Noah was commanded to take into the ark in order to preserve the species by him, (the raven for instance) the new continents were peopled with animals, as well

as vegetables, from their mountains; a fact which explains the phenomenon of the carcases of animals that now exist only between the *tropics*, being found in our superficial strata in the northern parts of the globe. At the time of the deluge these animals still existed in our climates, with all the other animals which, without having come out of the ark, exist in them at this day. The animals, which happened to be on the tops of the new mountains, spread themselves over the adjoining countries; but many underwent the same fate as the plants; they perished owing to the change of circumstances, and they propagated only in places where the new state of things was suitable to their natures. Hence it is that each distinct region is found now to have its peculiar plants and animals, a circumstance of considerable moment in geology, which I shall explain more fully hereafter, in treating of the *origin of organized beings* [1].

36. Every part of this sublime narration of Moses, is impressed with characters which refer immediately to the Author of nature himself. I have just stated the solemn *covenant* which God vouchsafed to make with the inhabitants of the new lands; the following sign was annexed to it: (Gen. ix. 12, 13.) "And God said: this is the *token* of the *covenant* between me and you, and every living creature that is with you, for perpetual generations; I do set my *bow* in the cloud, and it shall be for a *token* of a covenant between me and the earth." I shall first show what this great object presents to our notice,

[1] See a Dissertation on this subject, annexed to the Paris edition (1798) of the present work. Ed.

considered as it stands connected with physics and geology; after which, I shall speak of the proofs we have of the reality of this event.

37. I have already had occasion to remark, that *rain* does not proceed from the condensation, *by cold*, of the *water* raised by evaporation, but that it is produced by a chymical process, which is still involved in much obscurity. In the present state of our globe we observe two very different sorts of *rain:* the one which prevails over a large extent of country, either in a calm, or during regular winds; this rain is commonly foretold by the fall of the mercury in the barometer; it is always of some continuance, and is not accompanied with any other particular phenomenon: this I shall call *simple rain*. The other is local; and the barometer seldom announces it; its symptoms are sudden, and return by fits; it is always accompanied with *gusts of wind*, which also are local; often it ends only in *showers*, but sometimes it is attended with hail, thunder, lightning, and even with hurricanes. This I shall call *tempestuous rain*. It is to this latter kind of rain only that the *rainbow*, or Iris, belongs; for it requires that, at the same time when the air is clear in the part of the horizon where the sun happens to be, there shall be in the opposite part a *cloud*, very low and very thick, and that another *cloud* shall be so situated as to produce *rain* between the thick *cloud* and the spectator looking that way; circumstances that never happen in the case of *simple rain*, the clouds belonging to which are higher, and extend at once over a large tract of country: then also it *rains* or *snows* on the highest mountains; while in the case of tempestuous rains, we need not go to

a great elevation to have a tempest below us. When the simple rain ceases, the clouds every where break and disperse at once, without partial showers; while in the case of *tempestuous rains*, it often continues to rain for some moments in spots where the rays of the sun are falling, and where it is evident that the rain proceeds from the dispersion of the remaining clouds.

38. Thus, in order to decide certainly the question, whether the rainbow was known to the *antediluvians*, it would be sufficient to ascertain whether at that time there were any *tempestuous rains*. All we know in this respect is, that there is no mention of hail or thunder in all that Moses has said of the times anterior to the deluge, a circumstance which obliges us to consider this object upon physical and geological principles, in order to judge whether there be a possibility that the rainbow had not appeared before this revolution on our globe.

39. The *simple* and the *tempestuous rains*, unquestionably proceed from one common cause, by the operation of which much water is from time to time separated from the atmosphere, without however the hygrometer, (which marks the different degrees of humidity of the air, and by which we are enabled to determine the quantities of water corresponding to all the degrees of humidity of the air,) ever indicating the thousandth part of what then falls from some stratum of the atmosphere. This, I observe, is common to every kind of rain, and it affords a problem in meteorology which is far from being as yet resolved: but what we do perceive very clearly, is, that tempestuous rains, from all the phenomena which accom-

pany them, must necessarily have, besides the general cause, some particular causes of different kinds, or different degrees, depending, no doubt, on some mixtures of fluids, which at such times rise up in the atmosphere of the place in which they occur, or proceed from other spots, and originate in some particular state of the atmosphere itself. Now we know from geology, that at the period of the deluge, there happened very considerable changes, not only in the atmosphere, but in the *waters of the sea,* and in the nature of the lands; so that it is not unreasonable to suppose that the particular causes of the *tempestuous rains* have been produced by those changes; and that accordingly, when the rainbow appeared after the deluge, it was a new phenomenon, connected with a new state of the earth; a state more permanent than the preceding, and with regard to which that phenomenon became a real token of what God also declared to Noah at verse fifteen of the same chapter: "that the waters should no more become a flood to destroy all flesh;" that is to say, that beneath the new continents no such caverns should be formed as those into which the preceding lands sank, and when the sea consequently threw itself into a lower bed than that which it before occupied; a circumstance which, considering the successive effects which have brought about the present state of the earth, appears in itself highly probable.

40. Admitting this idea, that the rainbow then appeared for the first time, to Noah and his family, let us represent to ourselves how they must have been struck by the novelty and magnificent appearance of the phenomenon, and by the Divine revelation

which presented it to their notice, as the token of a covenant with them and their descendants; and then we shall no doubt find in the proof, that this impression was in fact produced, that of the reality of the event of which I have just shown the physical possibility. On this subject it is necessary to read that section of Mr. Bryant's "*Analysis of Ancient Mythology*," (vol. ii. p. 341.) that has for its title, "of Juno, Iris, Eros, and Thamur," in which the author unfolds what the ancient mythologies contain of allusion to this *sign*, as forming an era of the greatest importance in the history of mankind. The *Iris*, either as representing or accompanying *Divine love*, and even expressly as the emblem of a *solemn covenant*, became an object of *worship* among the first nations, distinct from the family of Shem; and Mr. Bryant gives a particular instance of this (p. 414 of the same volume,) in the design of a piece of sculpture, cut in the rock, near the *Campus Magorum*, in Persia, copied by Thevenot, in which *Eros*, that is to say, *divine love*, represented by a winged infant, is sitting on a *rainbow*, near which is the figure of an old man in the act of adoration. Lastly, Mr. Maurice, (at p. 347 of his work), quotes also the mythology of the Chinese, where they make their great deity Fohi to spring from a *rainbow;* and this personage, in other respects, bears all the characters and attributes of Noah, as saved from the deluge. Here then are pointed traits of a general tradition relative to the rainbow, considered as a great sign; and to this, *physics* and *geology* add their evidence. Now, if we consider the simplicity and conciseness with which Moses relates this circumstance, we shall find, that the Israelites

must have also known it, by tradition, from their progenitors, and it is a fresh proof that, through the whole of his account, he relied on this tradition.

41. There is also a very remarkable circumstance, which refers at once both to the history of the *flood*, and to the events that are related with respect to the *first man*; a connection that we have already noticed in the case of the plants which require cultivation to preserve them. In describing the *garden of Eden*, with the view solely of giving to the Israelites an account of the origin of evil, and of the remedy revealed by Divine wisdom, Moses mentions the following circumstances, (Gen. ii. 10, &c.): "And a *river* went out of *Eden* to water the garden, and from thence it was parted, and became into *four heads*; the name of the first is *Pison*, the name of the second is *Gihon*, the name of the third is *Hiddekel*, which goeth towards Assyria, and the fourth river is *Euphrates*." Here, I say, we have a description given by Moses in the second chapter of Genesis; and it could not but be present to his mind, when at the sixth chapter he began the history of the deluge. The Israelites, to whom he addressed himself, knew well one ASSYRIA and EUPHRATES, but these were very differently situated; no river existed in these countries that was divided into FOUR HEADS, of which one was *Euphrates*, and another ran towards *Assyria*: how then could they have borne this first apparent contradiction between the narrative of Moses and the facts.

42. We shall see here, from the very beginning of the Book of Genesis, what I have observed with regard to all the other parts to which I have had

occasion to refer, that the Divine source from which it is derived is rendered manifest even in its seeming *improbabilities*, when, taking a view of all its parts, we compare them with the whole assemblage of geological facts. At the second chapter, where Moses spoke of the *garden of Eden*, he was describing a place which had belonged to the ancient continents; but when, in the sixth chapter, he came to the history of the deluge, he begins with the declaration of God to Noah, that these continents should be destroyed. The Israelites, therefore, were not induced to make the observation I have just alluded to; they knew that the names *Assyria* and *Euphrates* were *antediluvian*, and only transferred to the new continents, as we have since seen it practised universally by colonies, who name the new settlements in the countries they adopt, after the correspondent names of their native countries[1]. Moses, in speaking of the garden

[1] It may be doubted whether this hypothesis is altogether satisfactory. The river Pison is mentioned Ecclesiasticus xxiv. 25; the land of Havilah, Genesis xxv. 18, 1 Samuel xv. 7; the river Hiddekel, Daniel x. 4, which is supposed to be Tigris. In Calmet's Dictionary, in the article Pison, or Phison, the writer observes: "We take it to be the Phasis, a famous river of Colchis." Moses says, (Gen. ii. 11, 12.) that it runs through all the land of Havilah, and that excellent gold is found there. The gold of Colchis is much celebrated. It has been thought that Moses expresses himself as if he wished to be understood to speak of lands and rivers that were extant at the time he wrote.

Another solution of the difficulty is given by Mr. Granville Penn, in his Comparative Estimate of the Mineral and Mosaical Geologies. The eleventh, twelfth, thirteenth and fourteenth verses of the second chapter of Genesis, containing the description of the rivers of Eden, "constitute a parenthesis intersecting the thread of narration, and introduced solely for the purpose of illustration."—"This," Mr.

of Eden, described a real place; for he could not be guilty of so gross a mistake as the contrary would imply: but this place existed no longer, since the continents on which it was situated had been *destroyed:* geology, even so far as it relates to the narrative of Moses, leads us to think that it was destroyed when ADAM and EVE, banished from the spot where they had transgressed the command of God, were compelled to apply themselves to agriculture for their subsistence. It is, I say, very probable, from the history of Moses, that a *volcano* burst forth to bar the entrance of this original place of their abode, while it sunk into the sea. I have shown that volcanic eruptions make a part of the history of the ancient sea, and Moses mentions a *flaming sword,* which guarded the entrance of the garden.

43. Lastly, after the account of the different circumstances of the flood, and of the first establish-

Penn says, " is manifest upon the face of the text." He considers " this illustrative insertion to have been originally a marginal gloss, which became incorporated into the text, either during the captivity, while the Hebrews were dwelling in the regions bordering upon the Hiddekel (or Tigris) and Euphrates, or after their return from that captivity." He remarks, that Bishop Lowth and Dr. Kennicott have treated of these glosses, and that " both the sacred testaments are known to have sustained such depravations in several instances." He then adduces an example of an incorporated gloss in the New Testament, noticed by Bishop Marsh, (Introd. to the New Test. vol. ii. p. 258.)

Should the respective solutions of Mr. G. Penn and our author be deemed inadmissible, it may not unreasonably be supposed that some portions of the antediluvian continents were, subsequently to the last revolution, abandoned by the waters of the sea. Further observations can alone decide the question: it would be necessary to find human fossil remains in the part preserved.—ED.

ment of Noah and his family on the new continents, Moses passes on to their posterity. He sets out with the first generations of the three sons of the great patriarch, to mark the course they pursued in forming their first settlements, whence we are able to trace the origin of the traditions of the deluge among the Pagan nations: after which, confining himself to the posterity of Shem, which was his principal object, he first attributes to Noah a length of life equal to what he had assigned to the antediluvians; he lived, he tells us, 950 years. From this time he represents the term of man's life as decreasing; accordingly, Shem's life was contracted to 600 years; nevertheless, in this course of successive decrease, ABRAHAM, the common father of the Israelites, and on whom he never ceases to fix their thoughts, is yet spoken of as having attained to the age of 175 years, after which the common term of human life was gradually shortened to its present duration. This is the last *geological* fact in the account of Moses, (the rest being only the history of the Hebrew nation) but it is well worthy of consideration.

44. The ancient mythologies of the Pagans, also assign very long lives to their first heroes; and after the account I have given of the origin of their idolatry, it is natural to think, that the real facts relative to this object, had so raised their imagination as to lead them to attribute *immortality* to these founders of the new race of mankind, and proportionally to augment the distance of time since they appeared on the earth. Every thing became gigantic in the ideas of these primitive people, as soon as their traditions had become the only sources of their knowledge; because

these contained real prodigies; and as thereby they disfigured more and more the facts themselves, it is not surprising that their chronologies are at length become pure fictions.

45. If Moses, as unbelievers suppose, had borrowed from these sources, can we bring ourselves to believe that he could have fallen into such a mistake as to drop the veil of antiquity in his chronology, so as to make in his address to the Israelites, but a few generations to have passed between Noah and the times of Abraham, their common father, at the same time describing the term of life of their ancestors as having decreased in this short period, from 950 to 175 years, with again a decrease of one-half, from the time of Abraham to that in which he wrote? No, it is not thus that designing people invent. It must necessarily be allowed that Moses relied on not being contradicted; and we now see that he spoke nothing but the truth, since our continents, that permanent assemblage of *chronometers*, confirm his chronology.

46. Here, again, some inattentive commentators on the book of Genesis, have, by the variety of their systems, given an increased weight to the arguments of unbelievers. It is not necessary for me to enter into these details, because I shall again show, that the literal sense of Genesis is the TRUTH: but I must for a moment stop to consider a point of importance on this head.

47. I have in view some chronological systems immediately deduced from the ancient astronomical monuments, under the idea, that nothing has happened with respect to the *motion* or *position* of the

earth that is foreign to the causes or laws which serve as a basis to astronomical computations. This supposition is very natural on the part of astronomers; but geology does not permit us to assent to it, because the revolution that occasioned the deluge must have had some influence on our globe in this respect. If we first consider the *statical* consequences likely to have followed from a sudden displacing of such a mass as the sea, we must judge that the *velocity* and *direction* of the motion of the parts of this mass, which happened to change their parallel, could not but have some influence on the *velocity* and *direction* of the motion of those parts of the globe to which they flowed, and on which they were detained, and thus occasion some change both in its *rotatory* motion, with respect to the *position of its poles*, and in the *inclination of its axis to the plane of its orbit.* Moreover, the continents having sunk down, and a portion of the waters of the sea having filled up vast caverns in the interior of the globe, there could not but follow some sensible alteration in its *centre of gravity*, and, consequently, in the direction of the *plumb-line* on some parts of its surface. These changes, doubtless, could be but small; however, they do not the less discredit *chronologies* which have for their foundation merely some *astronomical traditions* among Asiatic nations; because in those chronologies changes are ascribed to the *time* elapsed between the ancient and modern observations, which may have been produced in a very short space of time.

48. I have called *traditions* the astronomical fragments discovered among the people of Asia, because M. Bailly has proved that these fragments had an

origin prior to that of these people themselves [1]. Now, from all that I have hitherto proved, these traditions could proceed only from Noah; that is to say, from the first founder of the new race, and of this we have direct monuments in the ancient *mythologies*, where the great personage from whom they deduced all human knowledge, is, among other things, represented as having instructed them in *astronomy*. This also is the most probable reason why this science, not having its foundation in their own discoveries, but following the turn their fancies took in all other respects, degenerated into *astrology*. Such a gradual process may be traced in the works of Mr. Bryant, and Mr. Maurice, the latter of whom may especially be consulted at page 446 of his work.

[1] "Having examined and compared," says the author, "the formulæ of different nations, too distinctly situated to borrow from each other, M. Bailly found in all of them, the length of the year differently determined from what we know it to be. They consider it as consisting of 360 days; a difference which they superstitiously retain; but which they rectify in their calculations."—Lettres sur l'Education Religieuse, &c. § 150. He then proceeds to observe, that PH. HOWARD, in his Scriptural History of the Earth, has proved, from very striking characters, that these astronomical formulæ had been determined by the antediluvians, and that with great accuracy, in regard to the state of the earth at that period. The difference in question is to be accounted for, in De Luc's opinion, by small changes that have occurred in the earth's motions, and which he considered to have been, not the cause, but the consequences of the deluge.—Lettres sur l'Histoire de la Terre, &c. Vol. V. p. 619. Elem. Treat. p. 10. Mr. Howard has, moreover, shown that the evidently fabulous portions of the chronologies of the post-diluvians, were nothing more than the transformation into supposed portions of their history, of such astronomical periods as they had determined by retrograde calculations.—ED.

49. I now return to the *long lives*, both of the *antediluvians*, and of the first generations of men after the deluge, a circumstance for which it is not difficult to assign a physical cause, since we have already had occasion to notice considerable and successive changes among all classes of organized beings, before and after the deluge. These changes, the consequences of those that happened both in the interior and at the surface of the globe, were likewise the effects of the same causes that have produced so many greater effects of different kinds, of which I have given an account in these Letters; and we may readily conceive from analogy, that the long lives of the antediluvians were connected with the state of the earth; that the family of Noah, bringing with them to the new continents a great strength of constitution, communicated it to their first descendants, and that it diminished only by degrees. All is connected together by the same causes, in the long series of *geological phenomena*, including the history of *organized beings*; and it is those phenomena, which, drawing aside at this day the veil of mythologies and erroneous interpretations of Genesis, connect together all the parts of that cosmogony which is derived from the fountain of TRUTH.

50. As for the final causes, of which we can no longer doubt after so many proofs of the interference of God in the events of the earth, it is still easy to trace them in this account of the *duration of the life of man*. The first continents having been peopled only by the descendants of Adam and Eve, and the present continents by the family of Noah, we find, accordingly, a sublime agreement between the *long lives* of men in the first of those periods and the beginning of

the second, and the rapidity, as well of the population as of the advancement of the arts, of which we find such unaffected traces in the narrative of Moses; for it would be easy to prove that this *long term of life* more than quadrupled every effect that the same length of time would have produced among men whose lives would have been only of the present duration. But when the human race was renewed on continents which the sea could no more overwhelm, and had so multiplied, that men would by degrees crowd together on the same parts of the earth, it was a sublime dispensation of the wisdom of the Creator, thus to diminish the duration of human life, and thereby to shorten the reign of the passions of individuals.

51. In terminating here the physical explanation of the *eleven first chapters of* GENESIS, containing the history of the earth from the epoch when *light* was first added to the other elements which composed it, to the time of the calling of Abraham, I feel it proper to recapitulate the motives that have led me to the investigations of which these Letters contain the results. What can we determine with certainty respecting the *origin and nature of man,* without knowing his history? How can we know any thing of the *history of man,* except we know sufficiently the *history of the planet* he inhabits? How can we learn the history of this planet without studying the *monuments of its revolutions,* and all that natural philosophy can discover to us of their causes? Such are the questions that have induced me to devote near fifty years of my life to these studies, including the history of MAN himself; and as they have more and more strengthened my convictions of the truth of revealed religion, I have

found the reward of my labours in an inward satisfaction, which the vicissitudes of my life, although not inconsiderable, have never been able to destroy.

52. By inviting us in the Scriptures to the study of nature, God has provided the means of recalling men to faith in revelation, when the lapse of time and the restlessness of the human passions and imagination might lead them to unbelief. That faith had been successively established among mankind by the *miracles* of which they had been the witnesses, and the knowledge of which they had transmitted to their successors; and in our time it will be maintained by proofs of the past existence of the earliest and most important of these *miracles*, which will gradually dispel the obscurities produced by the fabulous accounts of nature, which the pretended instructors of mankind have propagated. Men will then universally acknowledge a SUPREME LEGISLATOR, who has given them precepts and laws; and they will at length be convinced of what importance it is to their welfare to regard HIM alone.

APPENDIX:

Containing Remarks on some Erroneous Representations relative to the Author, in a work entitled, " A Comparative Estimate of the Mineral and Mosaical Geologies."

To the unfeigned piety and the soundness of religious sentiments, which distinguished the author of the preceding work through every part of his long and useful life, all those who have known him can bear a willing and decided testimony. It is therefore difficult not to feel something more than surprise, on finding this venerable Christian philosopher branded with apostasy, in a work entitled " A Comparative Estimate of the Mineral and Mosaical Geologies," because, from a supposed " dread of the sarcasms of the physical philosophers," he had concurred in opinion with De Saussure on a well established and fundamental point of geology. He is represented as " vacillating," and as having resorted to a " fatal system of compromise and concession," (Comp. Est. p. 83.) for having adopted the opinion of that enlightened naturalist, that the mass of our continents is composed of strata of different genera and species, successively formed by chymical precipitations at the bottom of a liquid;

and he is accused of "surrendering the high and solid principle," maintained in the following passage of his earliest geological work :—'neither natural history nor physical science lead us to believe that our globe has existed from all eternity; whenever, therefore, it acquired its first existence, the matter of which it was composed must, in all necessity, have been of some nature and under some first integrant form.' It will scarcely be credited that such a charge should seriously be brought against a man, whose extraordinary personal efforts on the continent, successfully persisted in for several years, to unmask the pretended friends, and oppose the avowed enemies of Christianity, excited the admiration and gratitude of every sincere lover of the truth. (See Correspondance entre le Dr. Teller et J. A. de Luc.—Lettres aux auteurs Juifs d'un Mémoire adressé au Dr. Teller.—Précis de la Philosophie de Bacon.—Lettres sur le Christianisme, &c.) Indeed the professed object of his Letters to Prof. Blumenbach necessarily protect De Luc from similar charges. It were well, then, if Mr. Granville Penn had made himself better acquainted with the works of an author whom he so unjustifiably assails. He would have known that the "Introduction à la Physique terrestre par les fluides expansibles," contains a direct refutation of those principles, which led Fourcroy to rank the "creation of the world among the pious fictions invented by the authors of certain religious chronicles." De Luc has, in that work, shown in a very "uncompromising" manner, that from a profound study of the phenomena, the most undeniable traces of a *commencement* may be deduced in immediate opposition

to the doctrine of the "eternal march of nature," maintained by his infidel antagonist. (See Introduction à la Physique terrestre, &c. Vol i. pp. 153. 267, and 268.) In De la Métherie's own Journal, the ready vehicle at that disastrous period of opinions hostile to Christianity, De Luc openly asserted his belief that Revelation, when divested of the erroneous commentaries by which it is sometimes obscured, is as satisfactorily demonstrated by geological monuments, as any ancient historical fact can be by the documents that relate to it. Journ. de Physique, tom. xl. p. 455.

But we are told that the formation of the mineral strata by chymical processes, according to the laws of affinity and aggregation, "*favours the atomic* or *atheistical philosophy.*" Does De Luc, however, it may be asked, or do the naturalists mentioned by Mr. Granville Penn, while they recognize certain laws which regulated the arrangement of the elemental materials of the strata, hesitate to acknowledge that those laws were established by the Creator? The primary rocks exhibit the appearance of having been formed by crystallization in a liquid; and shall we say, when we see a salt crystallizing in a liquid, that it is in consequence of a direct act of the Divine will, and not by the effect of the affinities and the attraction of similar molecules, established by the Deity? The remark that "divine intelligence is questioned in proportion as secondary causes are supposed to execute functions which reason sees to pertain exclusively to a first cause," cannot be considered as applicable to the doctrine in question. How, again, is the hypothesis of the gradual process of precipitation and crystallization

according to the above stated laws, in necessary contradiction with the assertion, that "all material things seem to have been composed and variously associated in the first creation by the counsels of an intelligent agent?"—or how is that doctrine necessarily inconsistent with the belief, "that God endowed the particles of matter with such properties as most conduced to the end for which he formed them?" The very passage quoted by Mr. Granville Penn against De Luc, may be considered as expressive of the general principle on which all the physical deductions of our author are grounded.

"De Luc," he again remarks, (p. 53.) "abstained with a very curious reservation from employing the word *creation* in physical enquiries:"—'I shall not say created, because in physics I ought not to employ expressions which are not understood among men.' Lettres sur l'Histoire de la Terre, &c. Vol. ii. p. 211. Mr. Penn then proceeds to animadvert upon that passage in a strain of misplaced levity, no less unbecoming the gravity of the subject, than the respect due to so venerable a character as De Luc[1]. The meaning of the latter, however, has been entirely

[1] An equally intemperate tone prevails in Vol. i. pp. 241, 242. 2d edit. Mr. Granville Penn accuses De Luc of an intention to carry, "*by force or stratagem*, a point of system," and of having asserted, "with *a hardihood totally unaccountable*, that *ancient interpreters*, have for a long time remarked," that the Hebrew words signifying evening and morning, are used in the Book of Genesis to signify the beginning and end of a period of indefinite length. Mr. Granville Penn is here misled by a typographical error. In the Lettres sur l'Histoire Physique de la Terre, &c. p. 97, the words *interprètes antiques* had, by mistake, been substituted for *interprètes critiques*. See Errata at the end of that work.

misapprehended by Mr. Granville Penn, and may be gathered from another passage that occurs in the same volume [1]; where our author states his opinion, in concurrence with some of the deepest thinkers, that "the notions of (what we term) *non-existence,* and the transition from non-existence to (what we understand by) *existence,* altogether surpass man's capacity, and that in all likelihood, it is impossible for him to receive them in his present state." For this reason alone he considered it unphilosophical to employ, in physical researches, a word to which no distinct sense can be annexed. "That there was," he says, "a first intelligent Cause; that from that Cause the universe took its origin; that through its operation, in a word, the heavens and the earth were created in the beginning, man could learn, even from revelation, only as *facts;* being wholly unable to comprehend the principles upon which those facts depend." Our author's phrase, therefore, "*des expressions sur lesquelles on ne s'entend pas,*" simply conveys a belief that men cannot form to themselves any clear conceptions of the creative act, on account of the impenetrable obscurity with which that act is invested in the view of finite beings. It is evident that our author's observation so far from excluding, in reality implies, the idea of creation.

Regardless of the idiom of the French language, Mr. Granville Penn, in his animadversions upon De Luc, converts reflective verbs into personifications. He translates "se forma," "se formèrent," by *formed*

[1] V. pp. 634. 636. See likewise "Précis de la Philosophie de Bacon," Vol. ii. p. 128.

itself, formed themselves (p. 20); throwing those words into italic characters, with the apparent purpose of insinuating that a Divine and superintending intelligence was altogether overlooked in the systems of the mineral geologists. But does De Luc "question the intelligence of the Deity," when at the commencement of the third Letter of this Collection he observes, that "nature herself confirms that grand command of the Almighty, in the first chapter of Genesis with which the Mosaic history begins, "*Let there be light!*" and when he elsewhere says, that there is nothing in nature that can explain the origin of it? See also Letter III. §§ 7, 12, 19; V. § 8. and Introd. In such passages as these, our author not only "presupposes a first intelligent Cause," but "propounds," and "proclaims it like Newton;" (Comp. Estim. pp. 120, 121.) and on inspecting his other publications it will be seen that De Luc "not only proclaims it once," but "recurs to it repeatedly and constantly, as a first principle never to be lost sight of." With what shadow of candour then, or consistent reasoning can it be maintained, that "nature and chymistry" constituted the "first principle" of the philosophy taught by De Luc, and that the "mineral geology" which he adopted, "considered as a science, can do as well without God, as Lucretius did?" The efficient cause of affinities and attractions determining physico-chymical effects is always regarded by our author as independent of matter, inasmuch as he considers such affinities to be laws of motion impressed upon it by the Creator.

The general spirit, indeed, in which our author has attempted to explain and describe terrestrial

phenomena is, throughout the above work, entirely misapprehended and perverted by an erroneous interpretation, which confounds the determination of laws established by the Creator, with the supposed operations of a blind and fortuitous cause. To find a learned and estimable writer, like Mr. Granville Penn, labouring under such false and unworthy impressions in regard to De Luc, cannot but be felt as a subject of much regret; the more especially, as in other parts of his work, he seems duly sensible of the great merits of that philosopher [1].

It having been thus incumbent on the editor to advert to the "Comparative Estimate," he would here take occasion to observe further, that the mode of reasoning adopted by Mr. Granville Penn from the animal and vegetable, to the mineral kingdoms, with regard to first formations, appears not sufficiently close for the purposes of his argument.

"As the bone of the first man," says Mr. Penn, "and the wood of the first tree, whose solidity was essential, for giving shape, firmness, and support, to their respective systems, were not, and could not have been, formed by the gradual processes of ossification and lignification, of which they nevertheless must have exhibited the sensible phenomena or apparent indications; so, reason directs us to conclude, that primitive rock, whose solidity was equally essential for giving shape, firmness, and support to the mineral system of this globe, was not, and could not have been,

[1] "He was eminently distinguished, and his memory is deservedly honoured in the department of physics; he was great also in showing the concord of many natural phenomena with the Mosaic record of the deluge." p. 208.

formed by the gradual processes either of precipitation and crystallization, or of fusion and crystallization, notwithstanding any sensible phenomena apparently indicative of those processes, which it may exhibit; but that in the mineral kingdom, as in the animal and vegetable kingdoms, the Creating Agent anticipated in His first formations, by an immediate act, effects whose sensible phenomena could not determine the mode of their formation; because the real mode was in direct contradiction to the apparent indication of the phenomena." Vol. i. p. 83. 2d edit.

Now the reasoning drawn from the "fallacy of the authority of sensible phenomena," for deciding the mode of first formations in the two former kingdoms, does not seem conclusive when applied to the latter. It does not necessarily follow that "the principle determining the mode of first formations in two of them should have equal authority in the third;" the analogy which the animal and vegetable kingdoms bear to the mineral, is of too loose a kind to allow of our attributing the same origin to this kingdom also. There is besides greater *appearance* of the mineral kingdom having grown up by slow degrees, than there is of the same circumstance in regard to the two others [1].

[1] In "the first formations of the mineral matter of the globe," the ablest naturalists maintain that they perceive a *succession* of operations which necessarily require a certain time for their production. Micaceous schist, for instance, could not be formed at the same time as granite; serpentine, again, was produced at a later period, and the primary calcareous strata still later.

"If granite was in every instance composed in the same manner," observes Mr. J. A. De Luc, Jun., "and with a general uniformity of texture, we might suppose that it was so created all at once; but this very granite encloses cavities lined with crystals *(fours à*

The proposition of Newton, "that all material things were, in the beginning, created and set in order

cristaux,) cavities in which the three substances are separately crystallized, where the crystals of one substance penetrate into those of the others; where a rock crystal encloses amiantus, crystallized pyrites, chlorite, water, gases: will it be maintained that substances so widely different from each other, were formed simultaneously with the rock which encloses them? It is very natural to suppose that the enveloping substance is anterior to that which is enveloped; that the crystal which penetrates another is anterior to it.

"The succession of fossil animals frequently changing with the mineral formations, and having multiplied in each formation, from the most ancient fishes, or reptiles, or molluscæ, &c. indicates to us an interval of time consisting of many centuries previous to the appearance of man upon the globe; insomuch that the great theatre on which human events have taken place since the deluge, was not constructed all at once, but after the lapse of a long series of ages."

The phenomenon, however, of the most ancient breccias, or conglomerates, seems conclusive against adopting the supposition of a simultaneous formation of the primitive strata. It has been shown by De Luc and De Saussure, that very soon after the formation of the earliest of our strata on the bottom of the sea, its bed was the theatre of catastrophes frequently repeated, wherein strata already indurated underwent fractures and dislocations, which covered their surface with fragments, many of the pieces being rounded by trituration, and others remaining angular; and these fragments, being afterwards enveloped by the first of the succeeding strata, formed breccias, which were themselves afterwards covered with an accumulation of the same strata without fragments. Geol. Travels, Vol. i. Thus, between the class of granite and that of schists, brecciated strata are found; but the class of granite is there in great disorder, and all the fragments of the breccia are of that class; then follow the schists, among which no fragments are found, except in some parts of their mass, which had also been disturbed before it was complete. Between the schists and the lime-stone brecciated strata are also found, the fragments of which are of the class of schists, sometimes mixed with fragments of the class of granite; but before the lime-stone was produced, the schists had been much dis-

by God, with such sizes, figures, proportions, and properties, as most conduced to the end for which He formed them," does not involve the assertion that the properties and powers of all such things were *immediately* developed at the moment of their creation. It is not unreasonable to presume that had Bacon and Newton been contemporaries of De Saussure and De Luc, they would have acquiesced in the scientific views of these naturalists respecting the formation of the primary strata by chymical precipitations, views which the great progress that has been made in all the branches of physical knowledge during the last hundred years, had enabled them to take. It further seems a gratuitous assumption to say, that the mineral geologists virtually "represent God as creating matter in the most imperfect state."

"Every thing leads us to believe," (says M. FROSSART in his Accord entre le récit de Moïse et les phénomènes géologiques. Montauban, 1824.) "that in the arrangement of the earth's surface, God has permitted the slow agency of second causes. This opinion has not the slightest tendency to diminish in us the notion which we ought to hold of the power of the Creator and his infinite wisdom. It requires as miraculous an act to give laws to matter according to which it is to operate slowly and by succession, as to modify it suddenly······"

turbed. See De Luc's review of Dr. Hutton's Theory of the Earth, British Critic, Vol. viii. p. 348. 1796. Mr. Granville Penn having allowed certain periods of time for the formation of the secondary strata, such periods should likewise be applied to the formation of the primary strata, supposing these latter also to have been *gradually* produced, as the phenomena of the brecciated strata sufficiently prove to have been the case.

But, according to Mr. Penn, we are not left on this head to the deductions of reason alone. The sacred record teaches us, he says, that, " on the first day, by His Almighty *Fiat*, God caused all the first formations of the mineral matter of this globe, *in one immediate simultaneous operation*." Vol. i. p. 279, 2d edit.—" In the first sublime and comprehensive article, embracing the ' creation of the heaven and the earth,' the sacred historian summarily comprises the history of the *first formation of the entire mineral substance*, constituting the solid body of this globe." Vol. i. p. 180. Whether the words of the inspired writer justify such an interpretation on the part of Mr. Granville Penn, or whether this be not, also, an unwarranted assumption, the editor will leave to the decision of the judicious reader. There are not wanting expressions in the sacred records, which render it probable that God may have operated by the instrumentality of second causes; such as the following in Job (xxxviii. 4, 5.) " Where wast thou when I laid the foundations of the earth? ...... Who hath laid the measures thereof, if thou knowest? Or who hath stretched the line upon it?" Angels are said to be ministering spirits, Heb. i. 14.; and the terrific display at the promulgation of the law from Mount Sinai, was effected through the medium of angelic agency. Gal. iii. 19.

It has been justly observed [1], that the submarine processes during the period of time that elapsed from the Creation to the Deluge, and which is considered by Mr. Granville Penn as sufficiently long to account for the phenomenon of the fossils, "could not have

[1] British Review, Nov. 1825.

produced so regular an arrangement of strata, containing organic remains in a systematic succession of bodies, following each other in the order of their relative superiority."

THE END.

LONDON:
GILBERT & RIVINGTON, PRINTERS, ST. JOHN'S SQUARE.